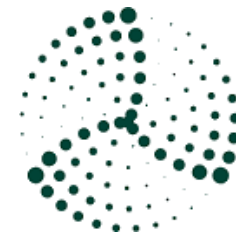


# FlexSys



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next



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- 1** What is FlexSys?
- 2** Real-world pilot
- 3** Surveys
- 4** Building simulations
- 5** Security of Supply

- 1** What is FlexSys?
- 2 Real-world pilot
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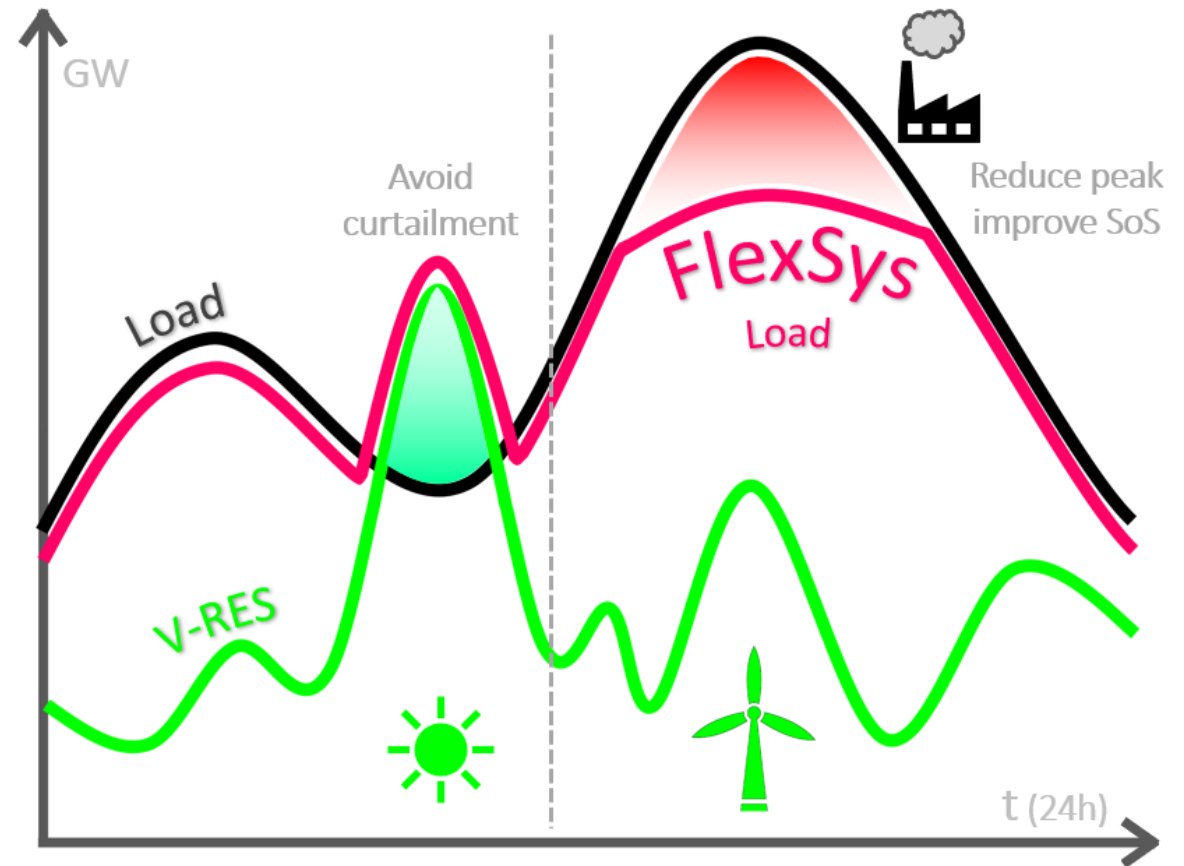
# The past ... and the future

Large **electrification** of energy consumption ahead

Likewise, large growth of **sustainable but intermittent** renewable energy production

Inflexible consumption poses a **risk for security of supply**

Flexibility changes **consumption from a liability into an asset**



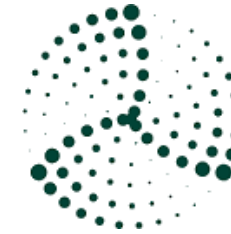


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Energy Economics

Building Physics Group

Electrical Energy Lab



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# Which questions did we ask in the FlexSys project?

How much do heat pumps **consume** in different buildings?

What is the **technical potential** of heat pumps to deliver flexibility?

How much can heat pump flexibility improve **security of supply**?

What can we learn from **surveys** and **testing out flex in practice**?

How much can a household **earn** from flexibility?

Which **barriers** hold back flexibility, what should **policymakers** do?

How do suppliers need to **adapt their business** processes?

How do we make flexibility **socially inclusive**?

[flexsys-project.be/deliverables](https://flexsys-project.be/deliverables)

1 What is FlexSys?

2 Real-world pilot



What

Results

3 Surveys

4 Building simulations

5 Security of Supply

# Real-world pilot

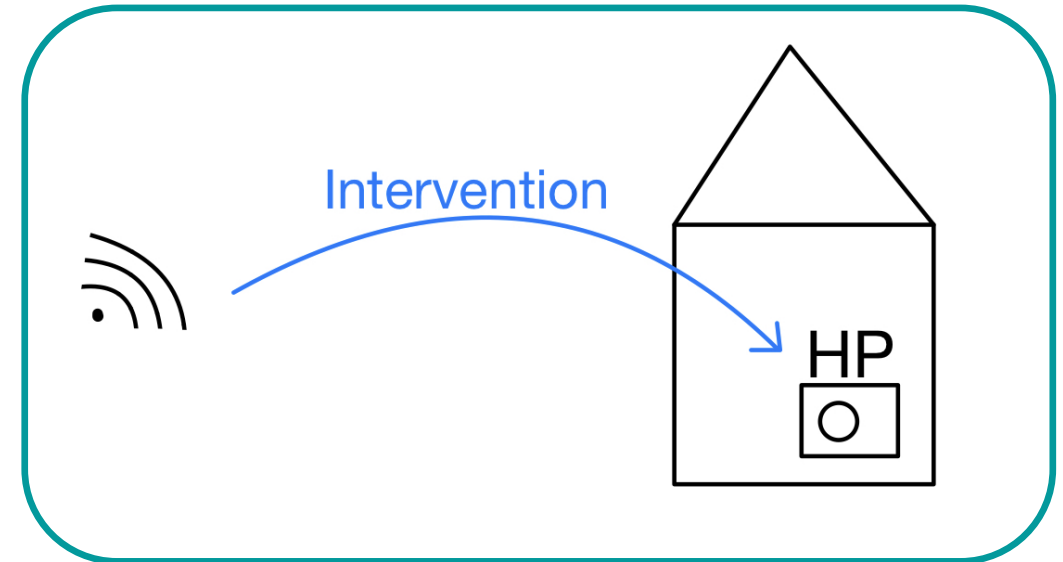
12 households with heat pumps around Ghent

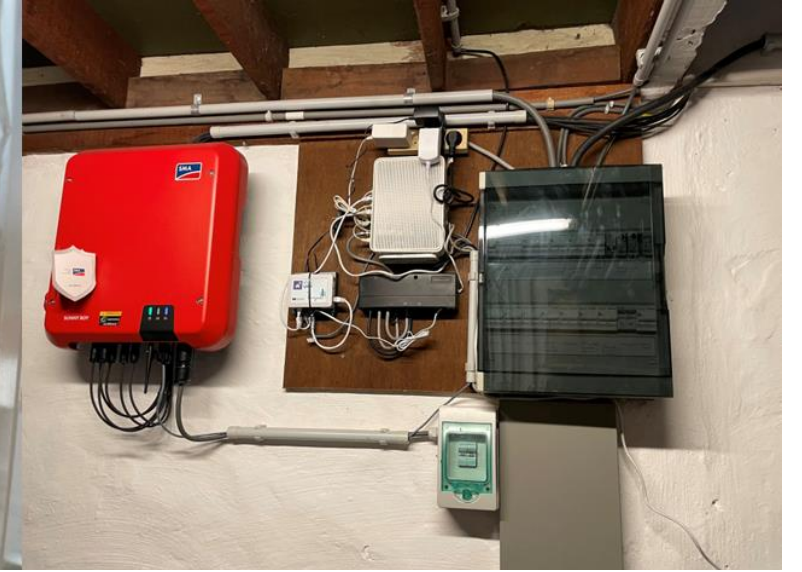
Heat pumps are made flexible using the COFYBox EMS

**Flex-interventions:**

“Heat pumps are turned off until the indoor temperature reaches 19 °C”

User can **overrule** using an app, but must provide the “reason why” in a textbox





**We got our hands dirty**



1 What is FlexSys?

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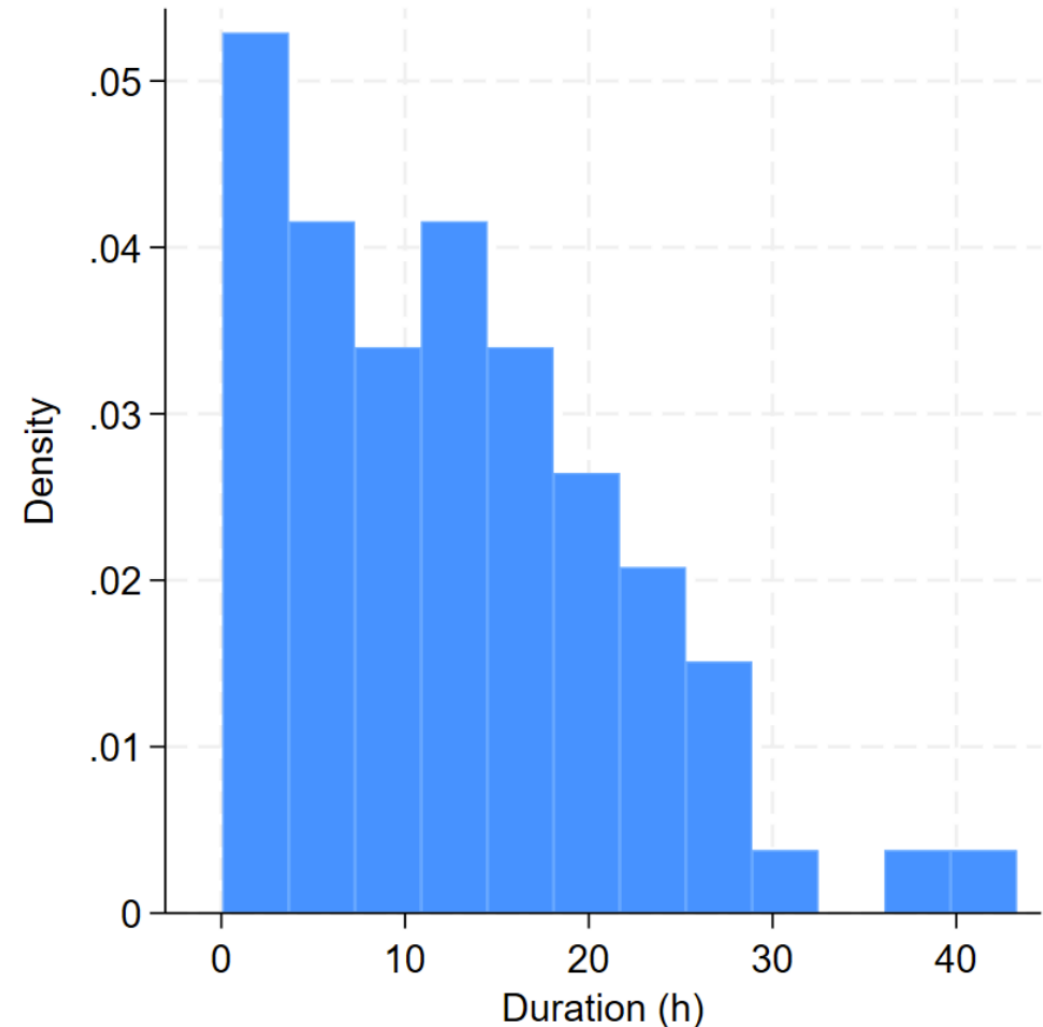
# Buildings with heat pumps cool down slowly

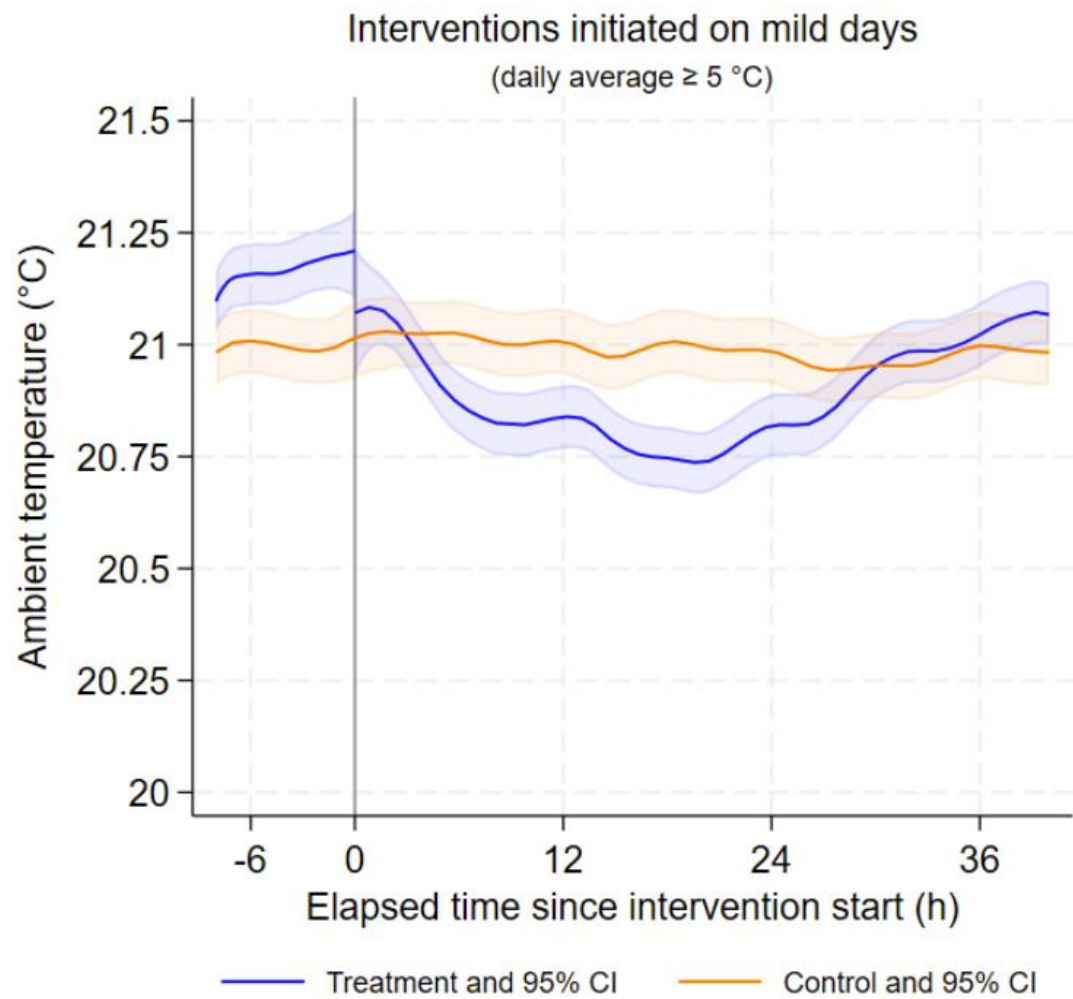
After a heat pump is turned off, it often takes **more than 10h, even 20h**, for the building to cool down by a few degrees

The observed durations could have been even longer, but in the pilot:

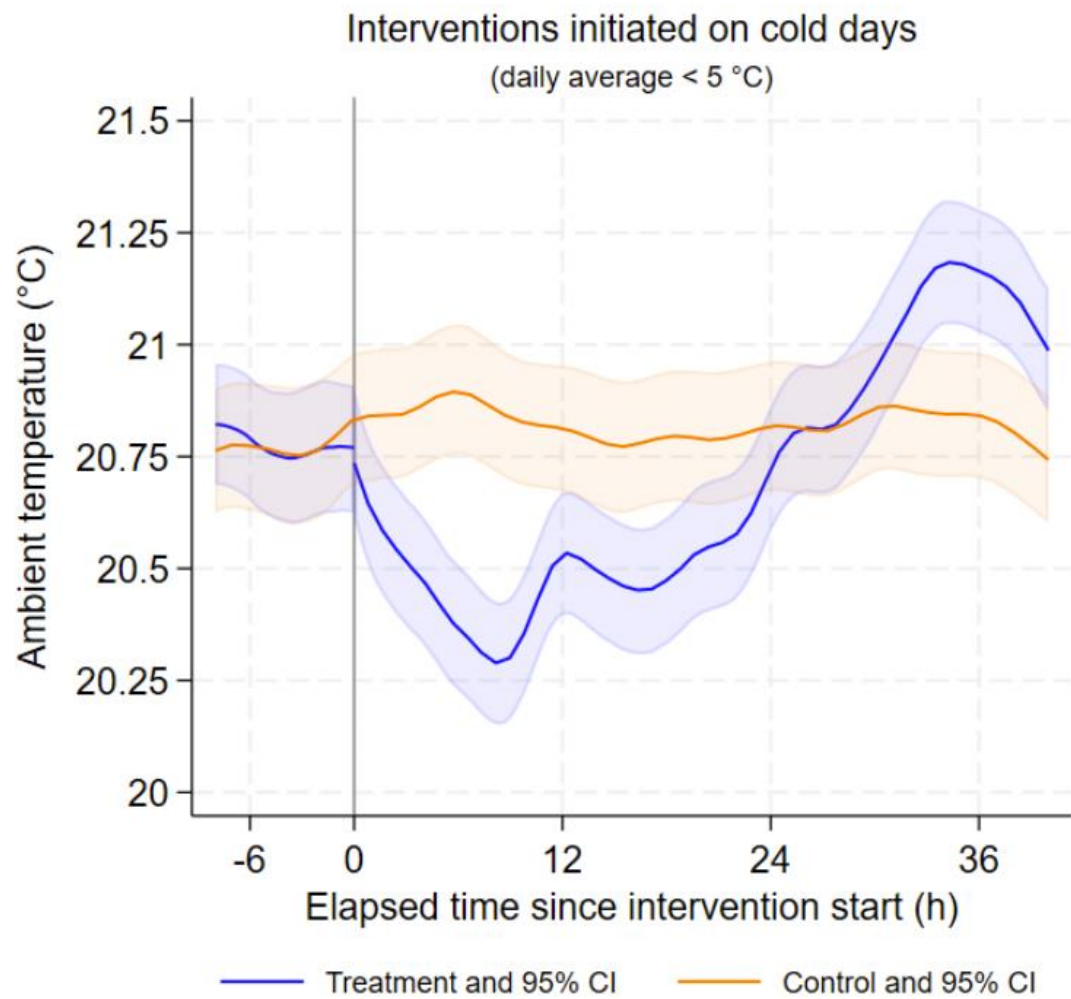
The cool down of the **sanitary hot water tank** could itself trigger heat pump reactivation

Participants often reactivated heat pumps manually by **'overruling' flexibility**

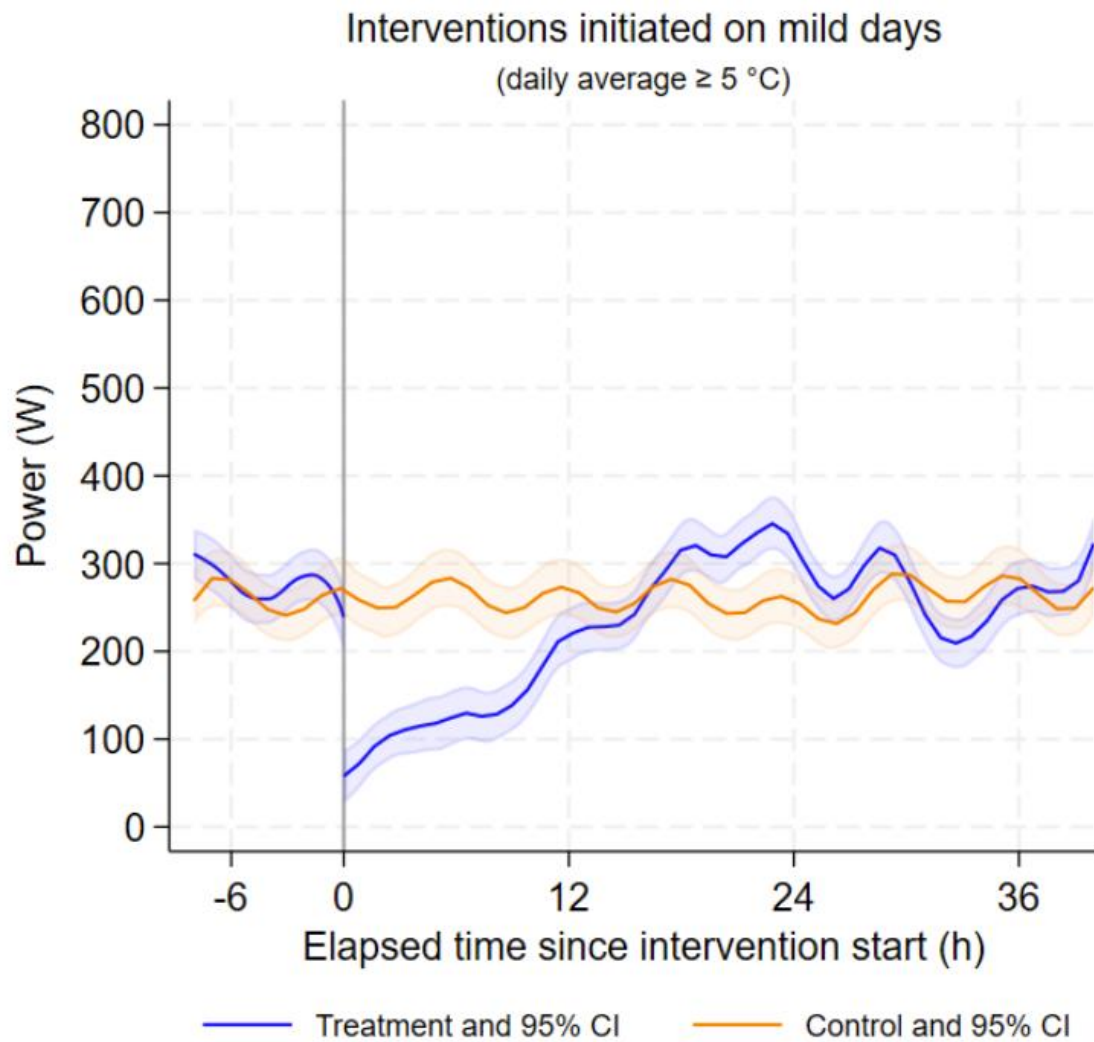




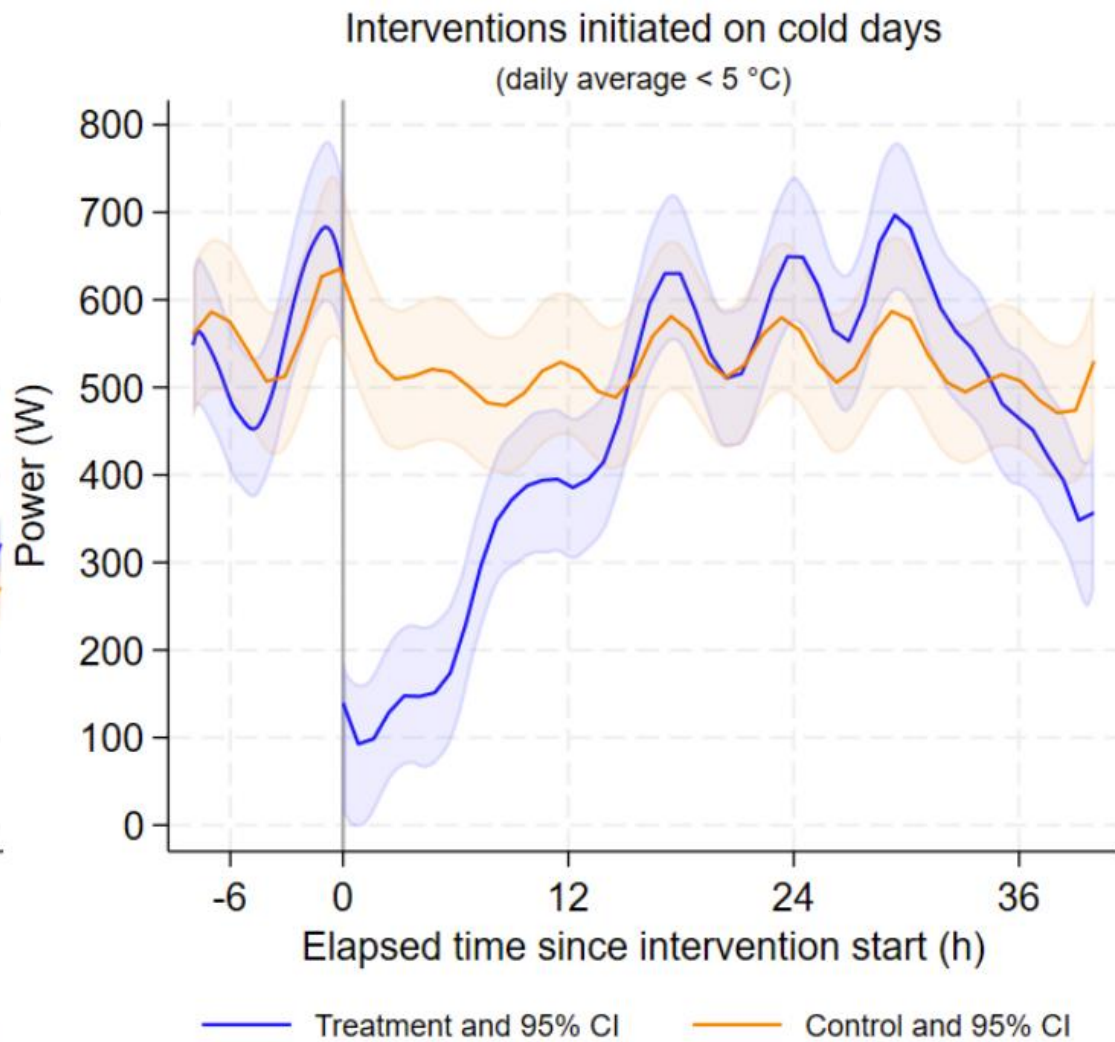
Mild days



Cold days



Mild days



Cold days

# What else did we learn from our pilot?

Some - but not all - people care about **being warned** beforehand that their heat pump will be turned off

If you give people the ability to **override**, they use it, although not very frequently

People give **all kinds of reasons** for overruling flexibility

People enjoy having access to an online **platform** that gives them better **insight** into what's happening with their heat pump and why

- 1 What is FlexSys?
- 2 Real-world pilot
- 3 Surveys**
- 4 Building simulations
- 5 Security of Supply



1 What is FlexSys?

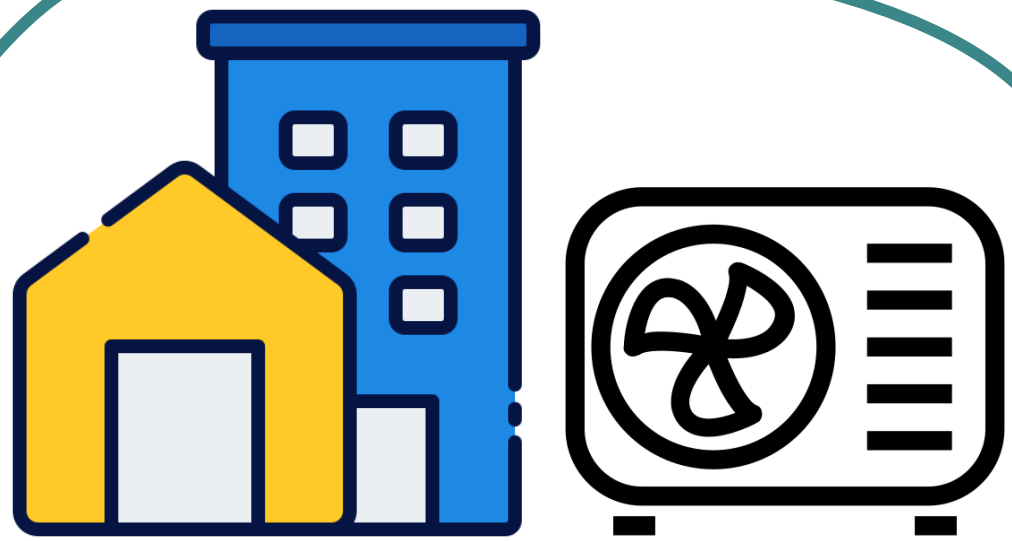
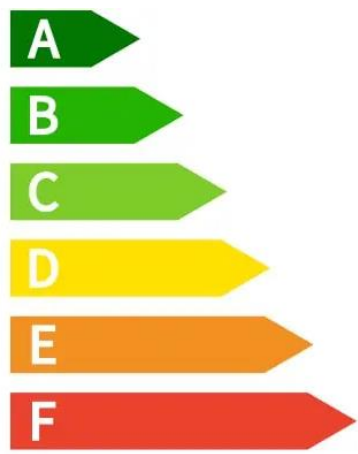
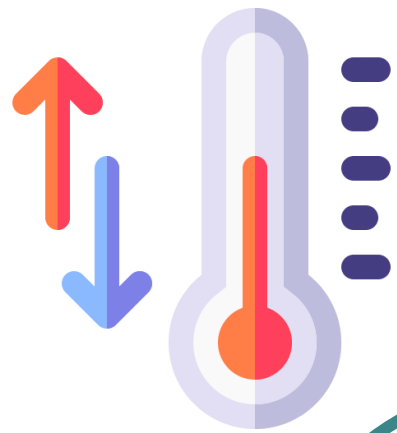
2 Real-world pilot

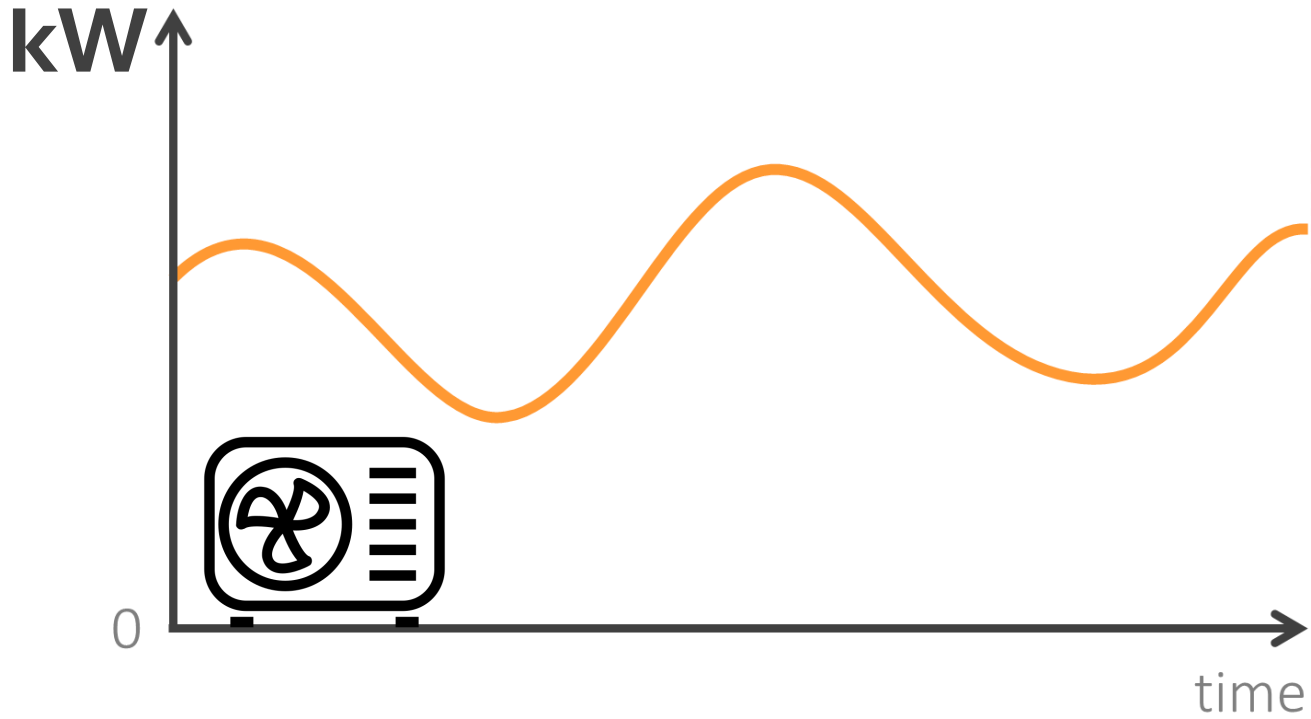
3 Surveys

4 Building simulations



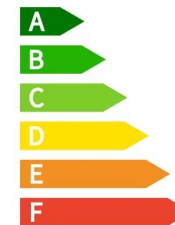
5 Security of Supply





**Heat pump electricity consumption profile under normal operation**

**For 66 types of residential buildings**



# Heating a home with a heat pump for one hour:

## Assumptions behind the table:

- Air-to-water heat pump
- The indoor temperature that needs to be maintained is 21°C

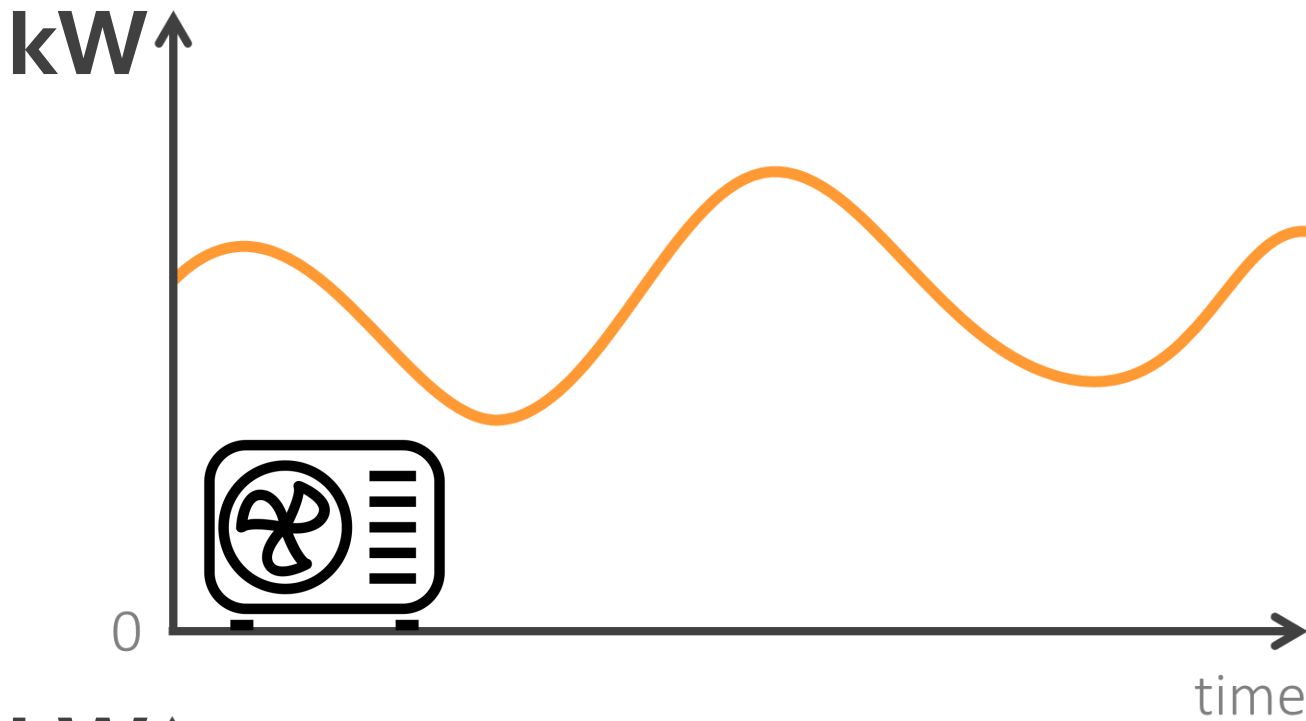
## Example of what is in the table:

If a **medium-sized detached home** with a building envelope **label B** wants to maintain an indoor temperature of 21°C for one hour, while it is **0°C outside**, then:

- electricity consumption of the heat pump will be **2.4 kWh<sub>e</sub>**
- amount of heat released to the building will be **7 kWh<sub>th</sub>**
- COP will be **3**

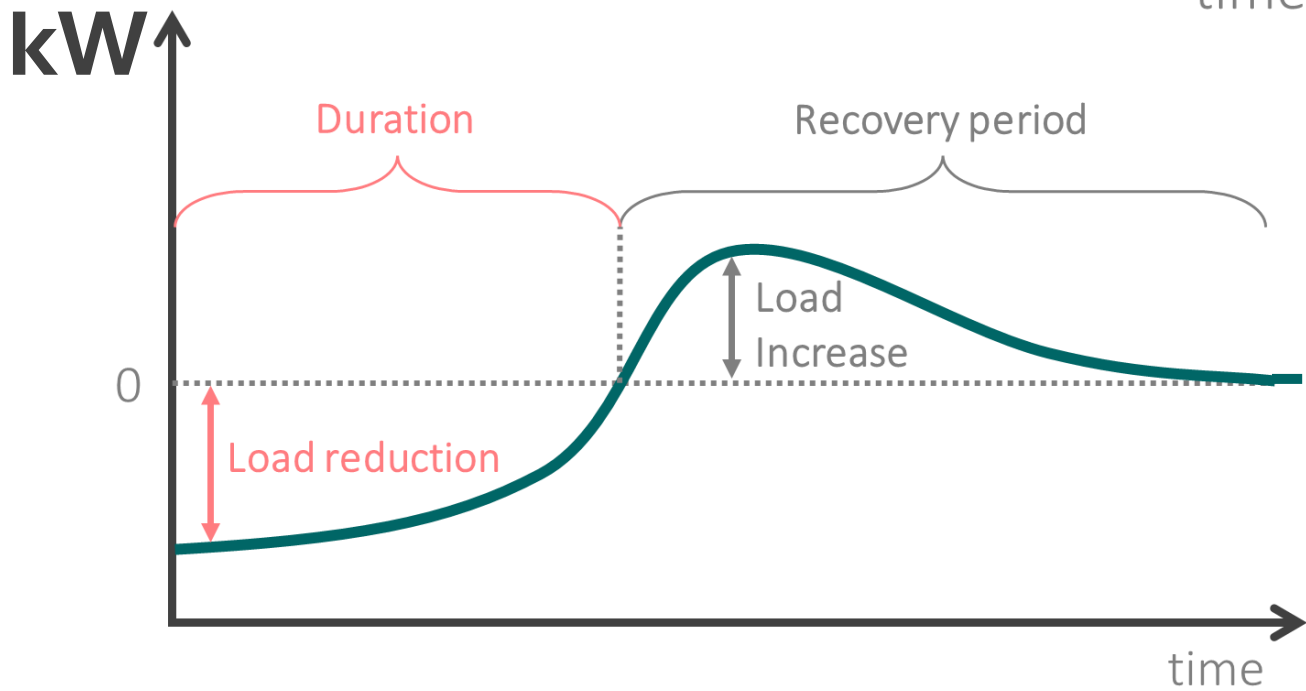
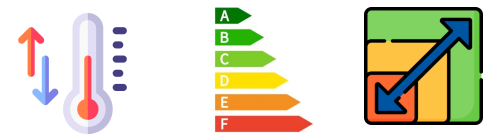
Building Type	Building Volume (m <sup>3</sup> )		Building Area (m <sup>2</sup> )		Building Envelope Label	Heat pump electricity consumption (kWh <sub>e</sub> )			Heat production (kWh <sub>th</sub> )			COP (kWh <sub>th</sub> /kWh <sub>e</sub> )		
						-5°C	0°C	5°C	-5°C	0°C	5°C	-5°C	0°C	5°C
Apartment	300	M	100	M	A	0.8	0.6	0.2	1.8	1.6	0.9	2.3	2.8	4.8
Apartment	300	M	100	M	B	1.3	0.7	0.3	2.7	2.1	1.4	2.2	3.0	4.6
Apartment	300	M	100	M	C	1.4	0.8	0.3	3.0	2.1	1.3	2.1	2.6	4.3
Terraced	437	S	126	S	A	1.6	0.8	0.4	3.6	2.8	1.9	2.2	3.3	5.0
Terraced	437	S	126	S	B	2.3	1.4	0.6	5.2	4.1	2.9	2.3	3.0	4.6
Terraced	437	S	126	S	C	3.2	2.0	0.9	6.9	5.3	3.6	2.1	2.6	4.2
Terraced	475	M	160	M	A	2.0	1.0	0.4	4.5	3.3	2.0	2.3	3.4	5.1
Terraced	475	M	160	M	B	3.0	1.8	0.8	6.9	5.4	3.6	2.3	3.0	4.7
Terraced	475	M	160	M	C	4.2	2.4	0.9	8.8	6.5	4.0	2.1	2.6	4.3
Terraced	547	L	199	L	A	1.9	1.0	0.4	4.4	3.4	2.1	2.3	3.4	5.1
Terraced	547	L	199	L	B	2.9	1.8	0.8	6.8	5.3	3.6	2.3	3.0	4.7
Terraced	547	L	199	L	C	4.2	2.5	1.0	9.0	6.8	4.3	2.1	2.6	4.3
Detached	460	S	146	S	A	2.0	1.1	0.5	4.8	3.8	2.7	2.4	3.4	5.1
Detached	460	S	146	S	B	3.2	2.0	0.9	7.6	6.0	4.4	2.4	3.0	4.7
Detached	460	S	146	S	C	4.7	2.9	1.3	10.2	7.8	5.7	2.1	2.6	4.2
Detached	622	M	198	M	A	2.3	1.2	0.6	5.7	4.5	3.2	2.4	3.4	5.1
Detached	622	M	198	M	B	3.8	2.3	1.1	9.0	7.0	5.2	2.4	3.0	4.7
Detached	622	M	198	M	C	5.6	3.3	1.6	12.1	8.5	6.8	2.1	2.7	4.2
Detached	798	L	277	L	A	2.8	1.6	0.8	6.9	5.5	3.8	2.4	3.4	5.1
Detached	798	L	277	L	B	4.6	2.9	1.4	11.1	8.8	6.4	2.4	3.0	4.7
Detached	798	L	277	L	C	7.0	4.3	2.0	15.0	11.6	8.3	2.1	2.7	4.2

**Disclaimer:** COP is not exactly equal to heat production divided by electricity consumption because the table shows values rounded up to one value behind the decimal point, leading to rounding errors

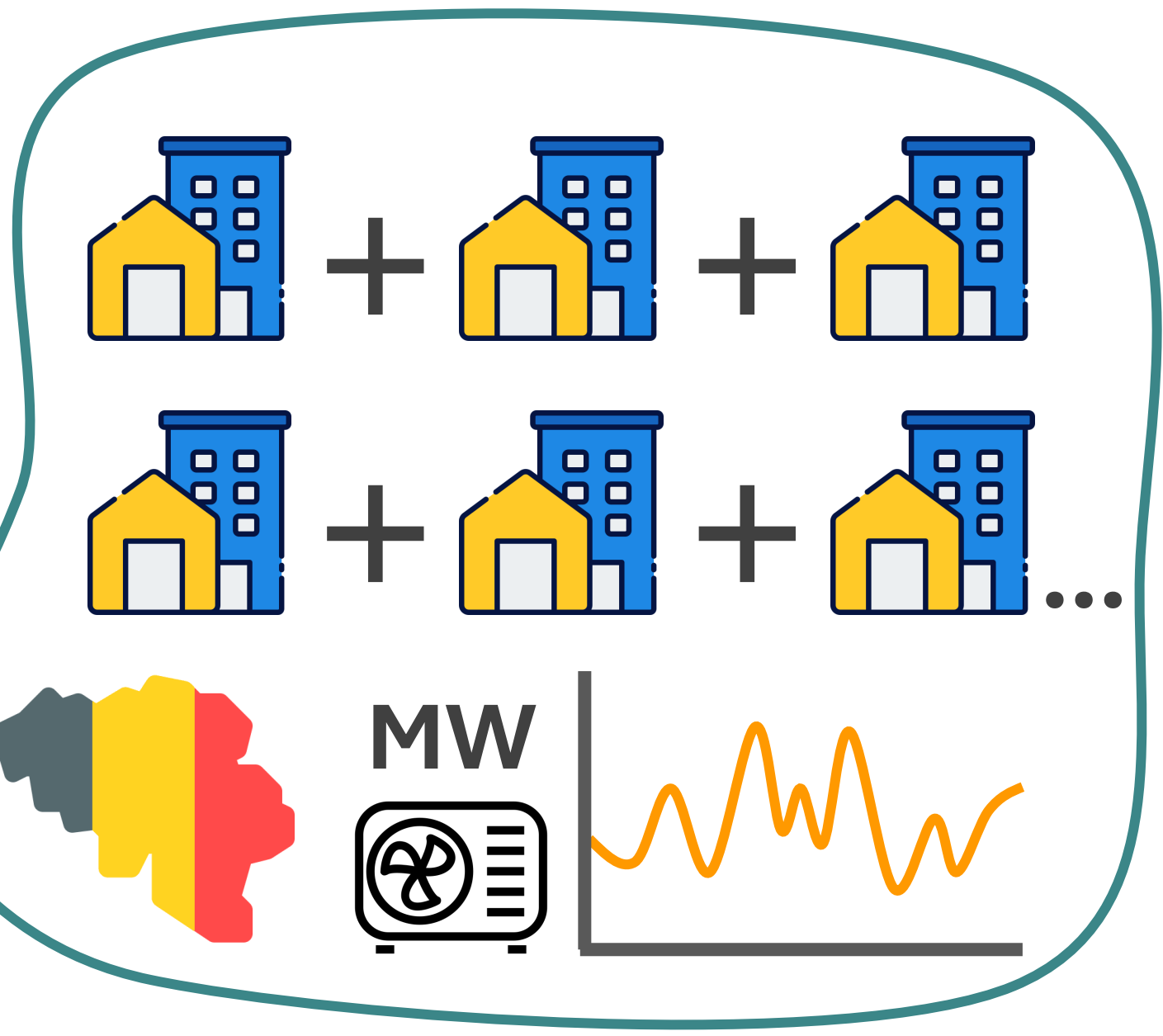


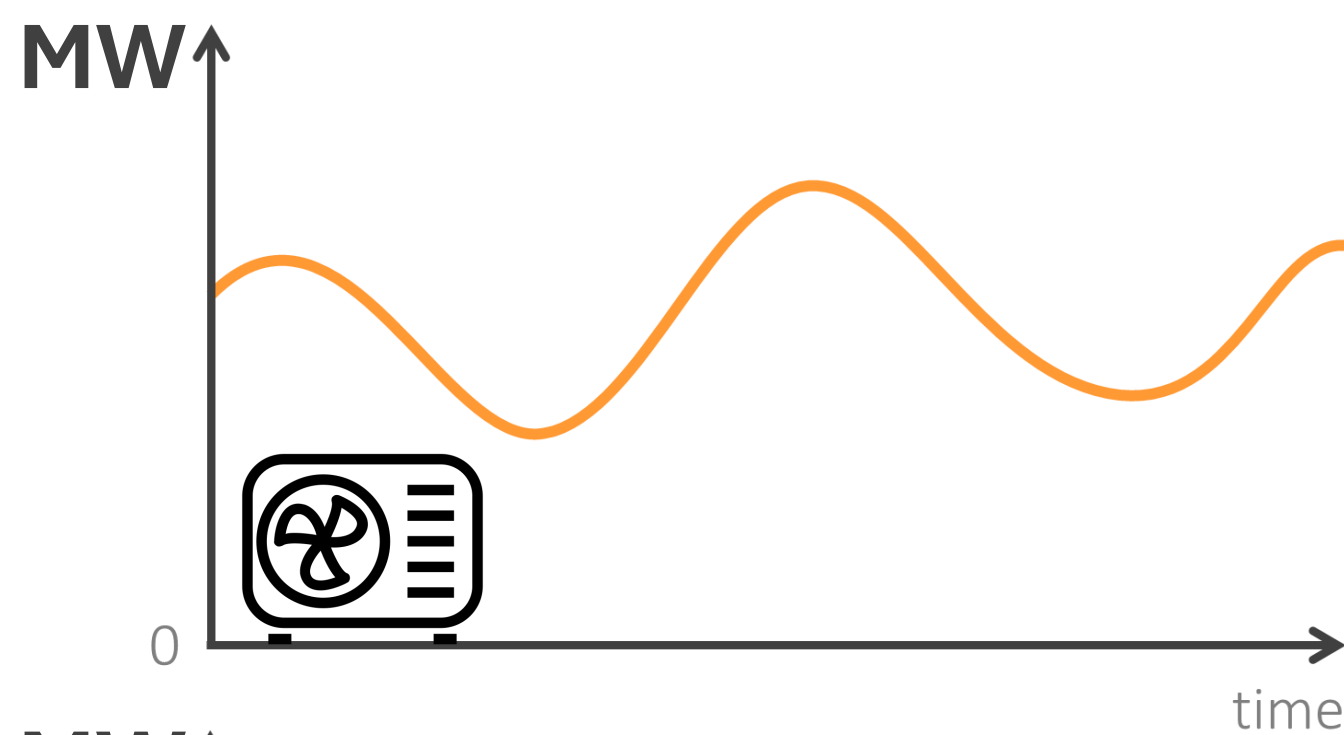
Heat pump electricity consumption profile under normal operation

For 66 types of residential buildings



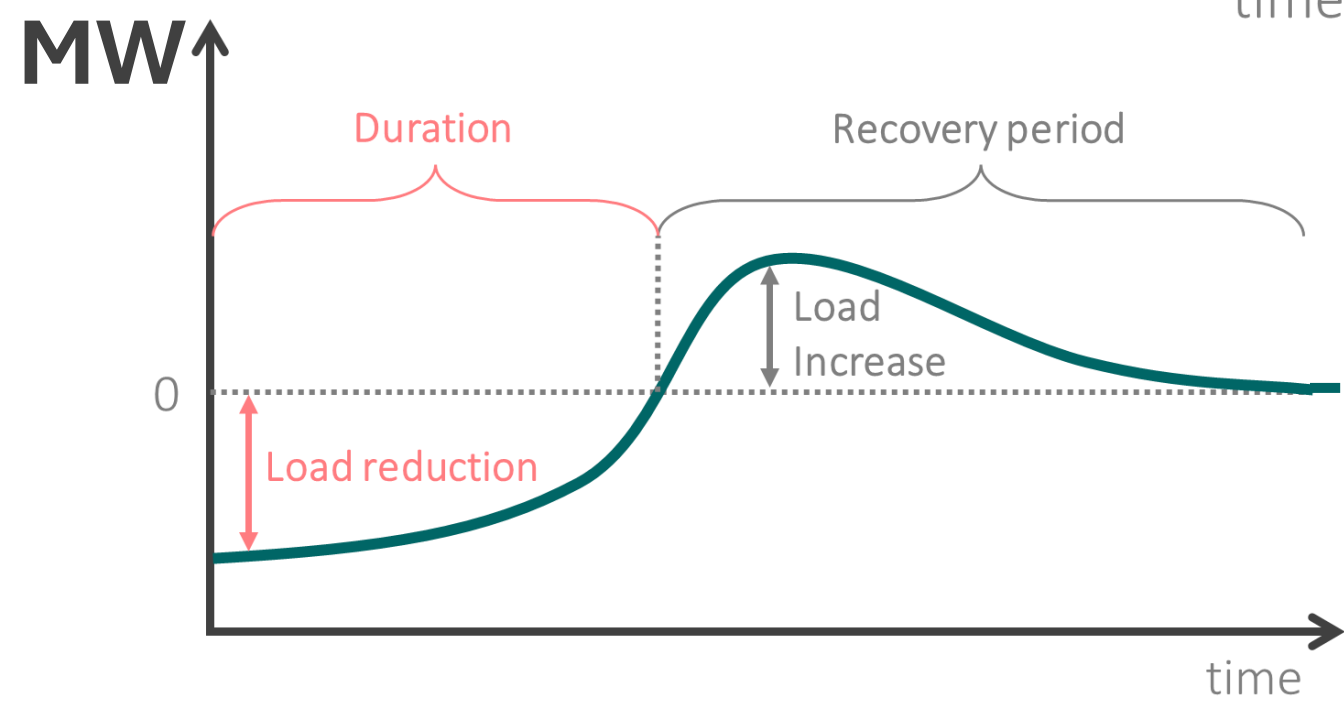
Change in the electricity consumption of the heat pump compared to normal operation





Electricity consumption under normal operation

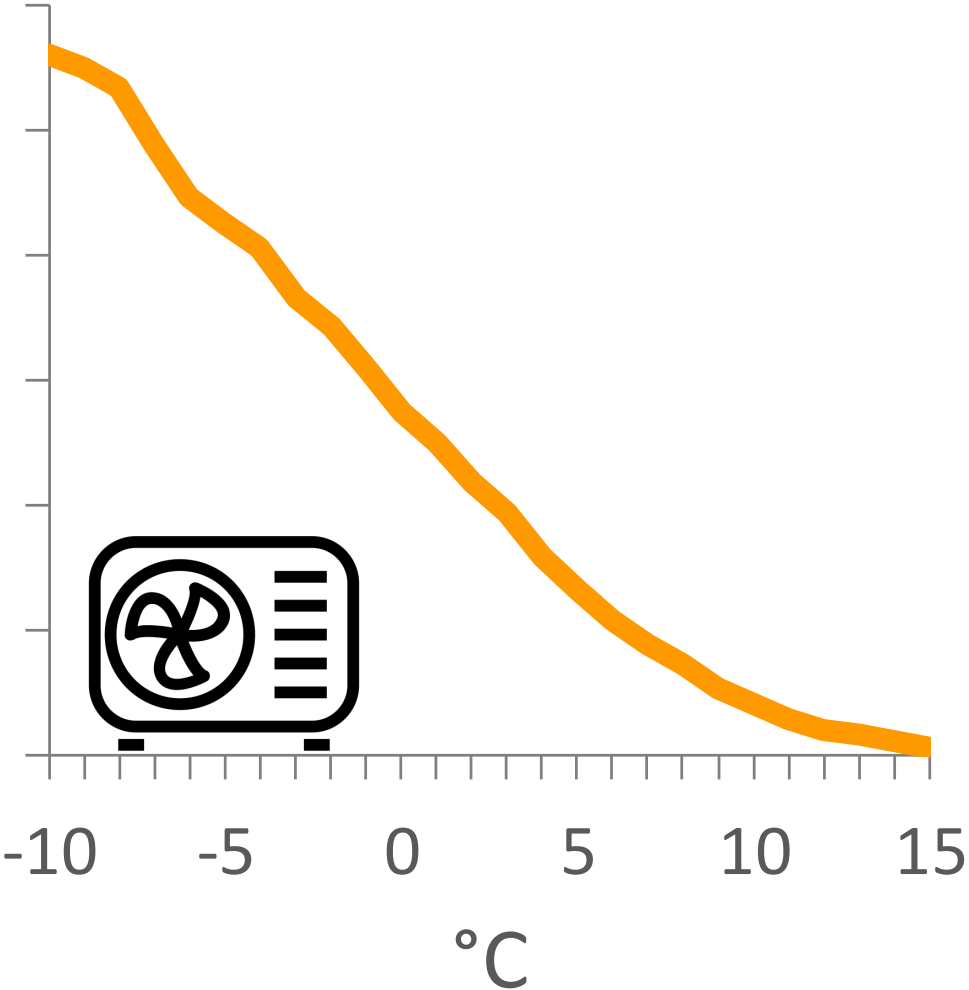
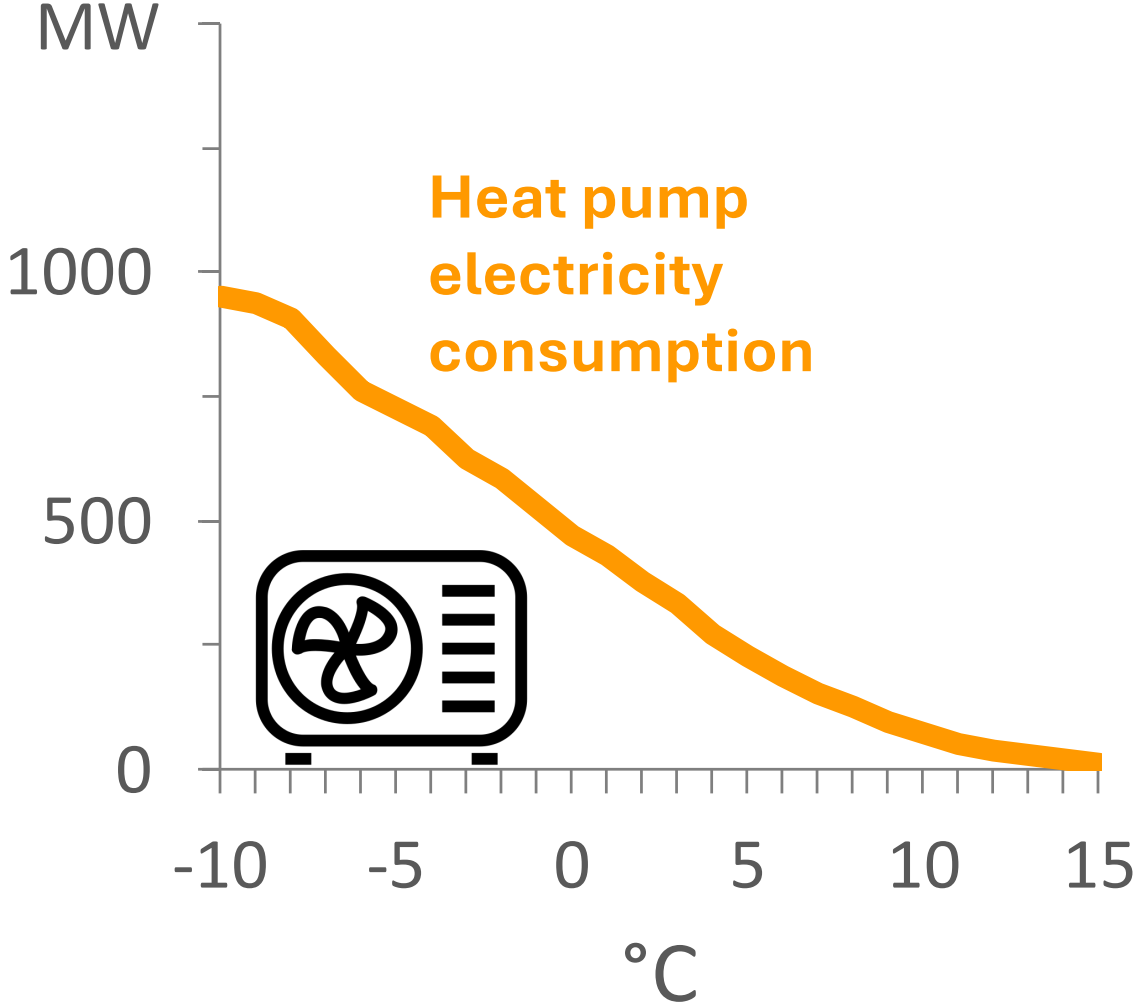
For the whole Belgian heat pump fleet in 2030 and 2034



**Change** in the electricity consumption of the heat pump compared to normal operation

2030

2034

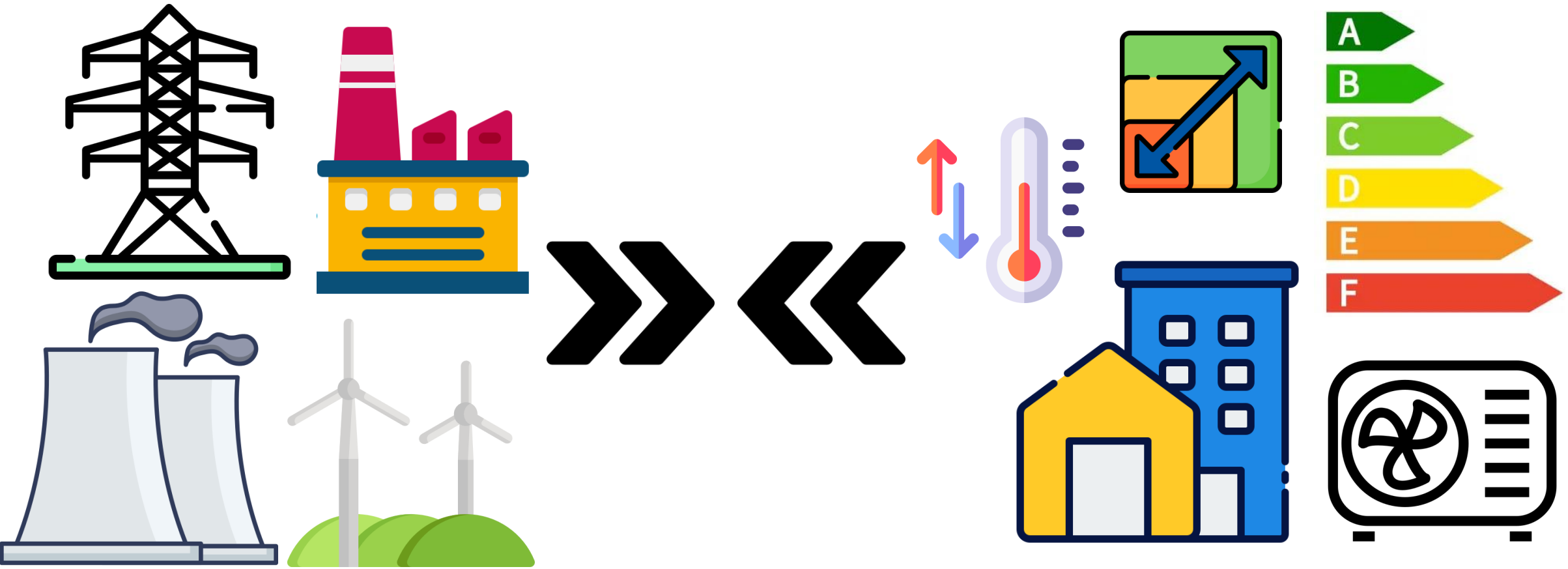


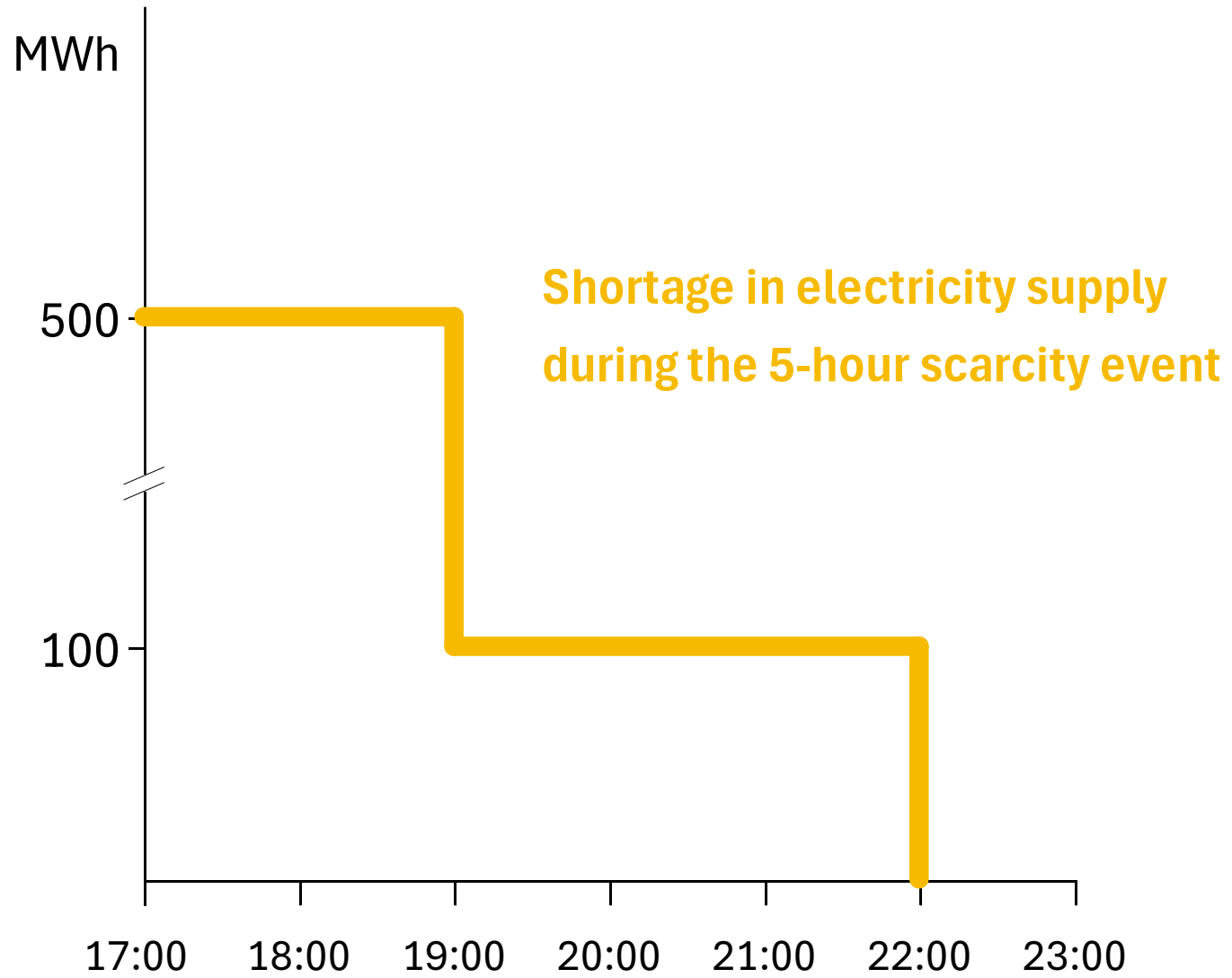
- 1 What is FlexSys?
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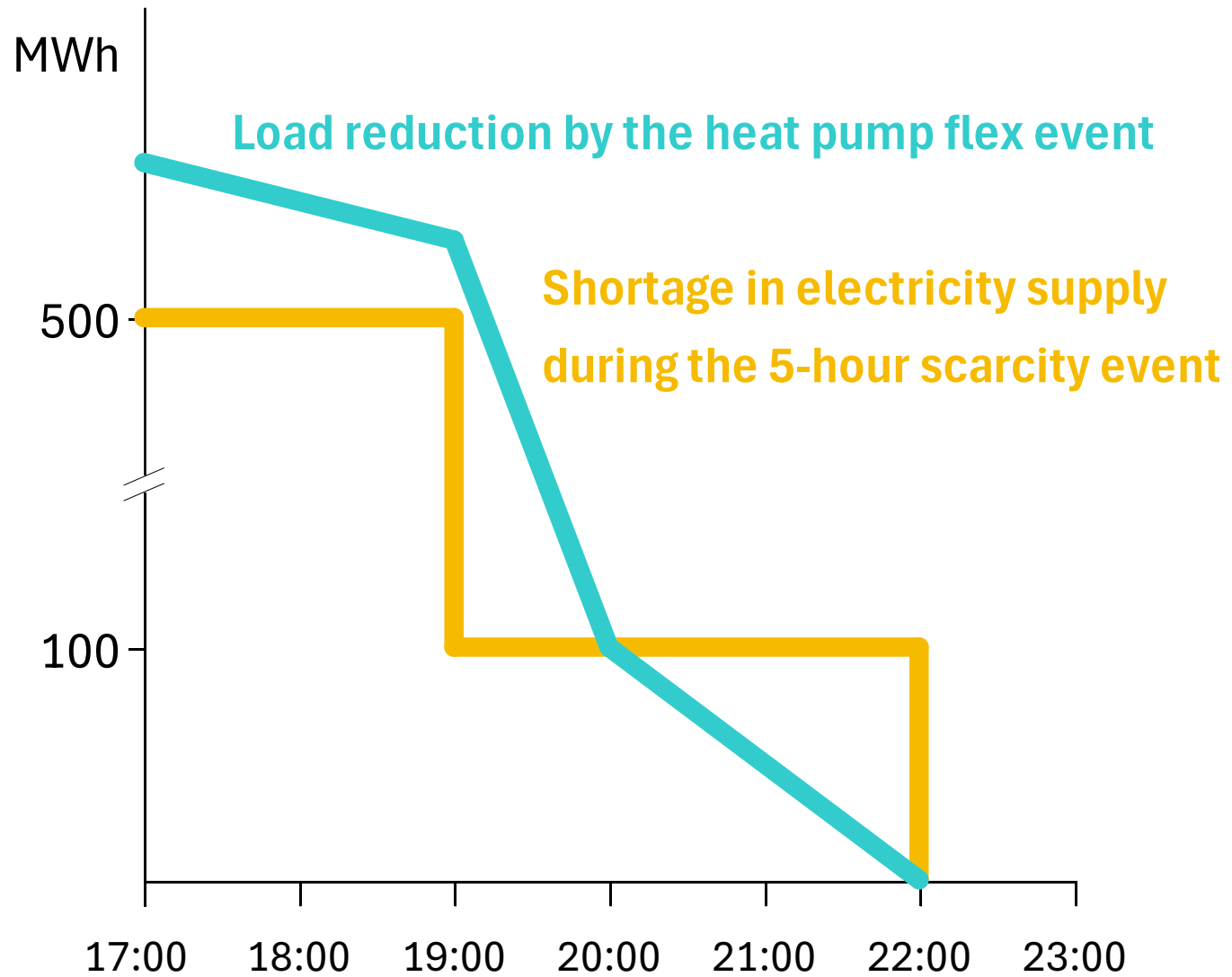
# Why is heat pump flexibility potentially interesting for Security of Supply?

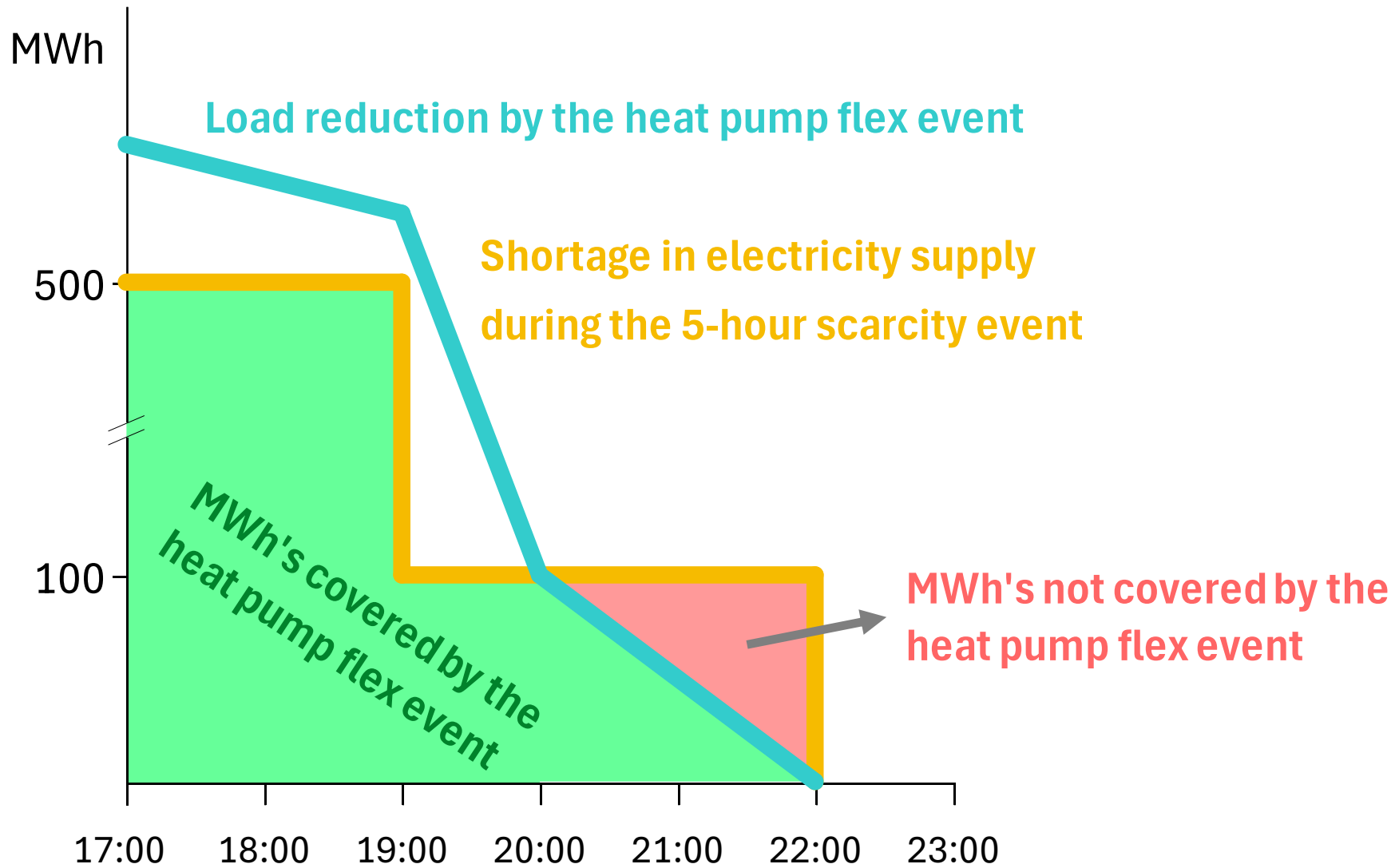
- Like an EV, a heat pump uses 2000-3000 kWh/year
  - Unlike an EV, consumption is concentrated in **winter**
  - Consumption is highest of all during the **coldest days**
- => Good reasons to suspect that heat pumps are well-placed for and could contribute to SoS**

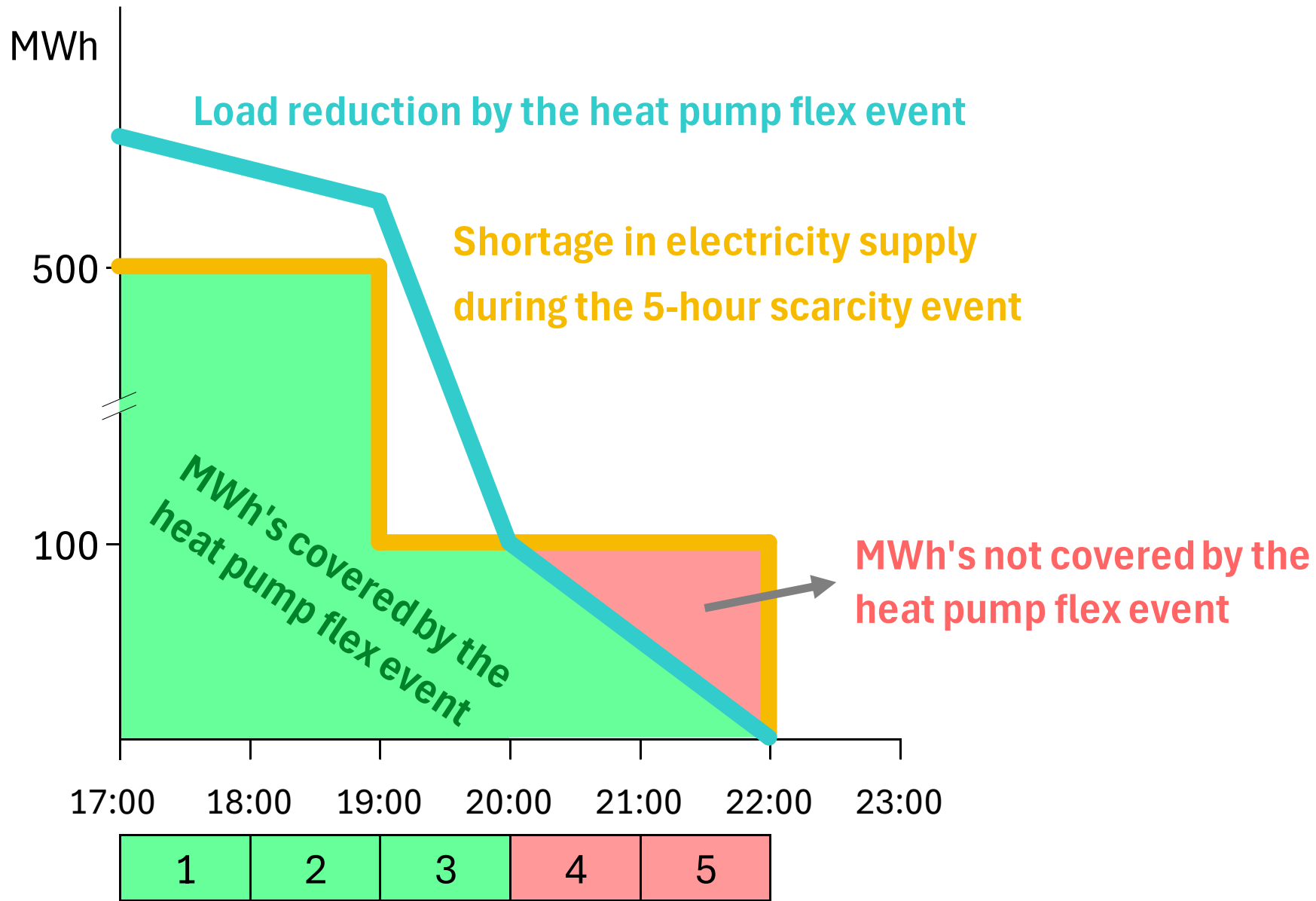
# Connecting simulations of the electricity system with building simulations



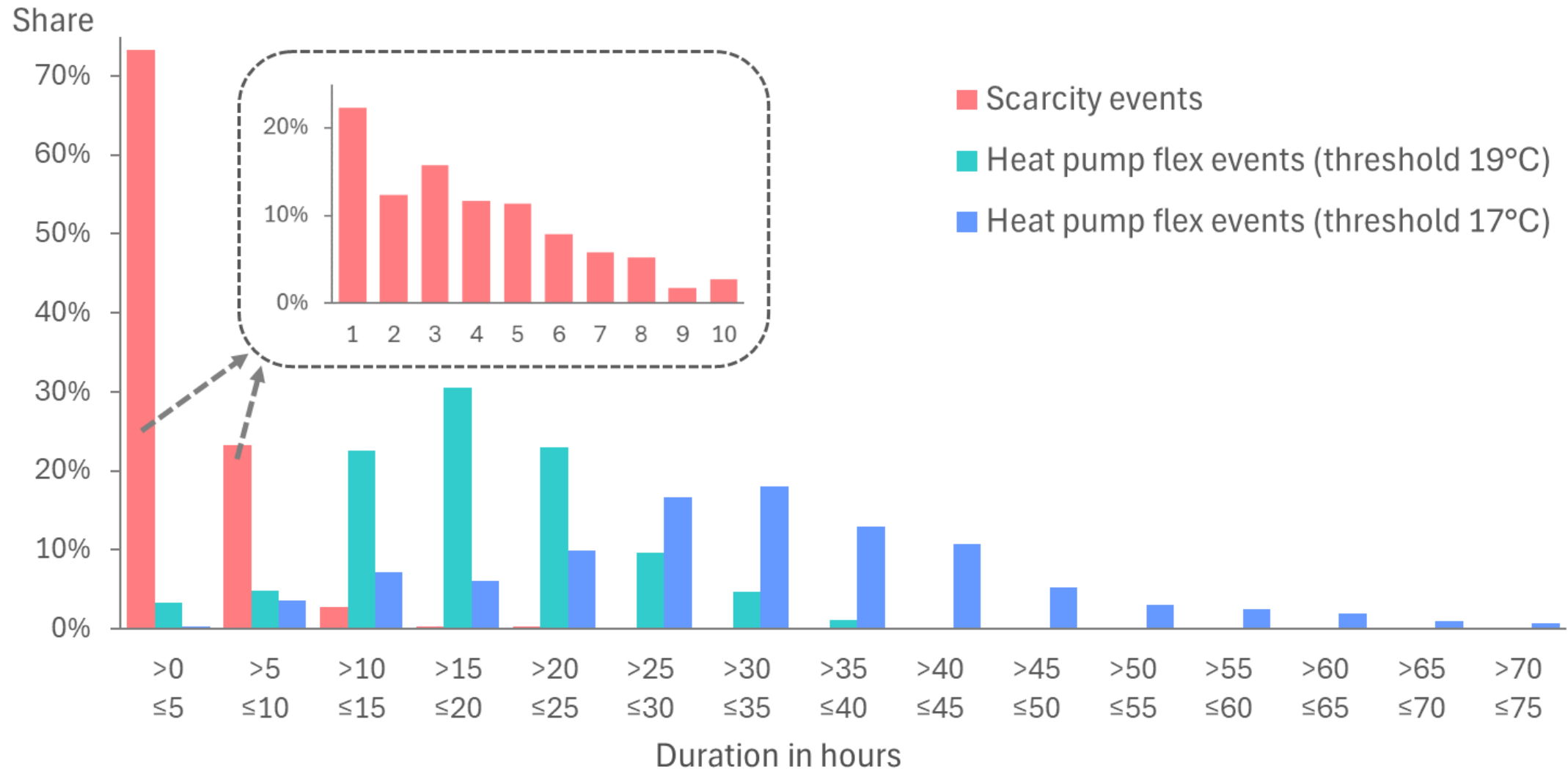








# Scarcity events only last a few hours, heat pump flex can last much longer

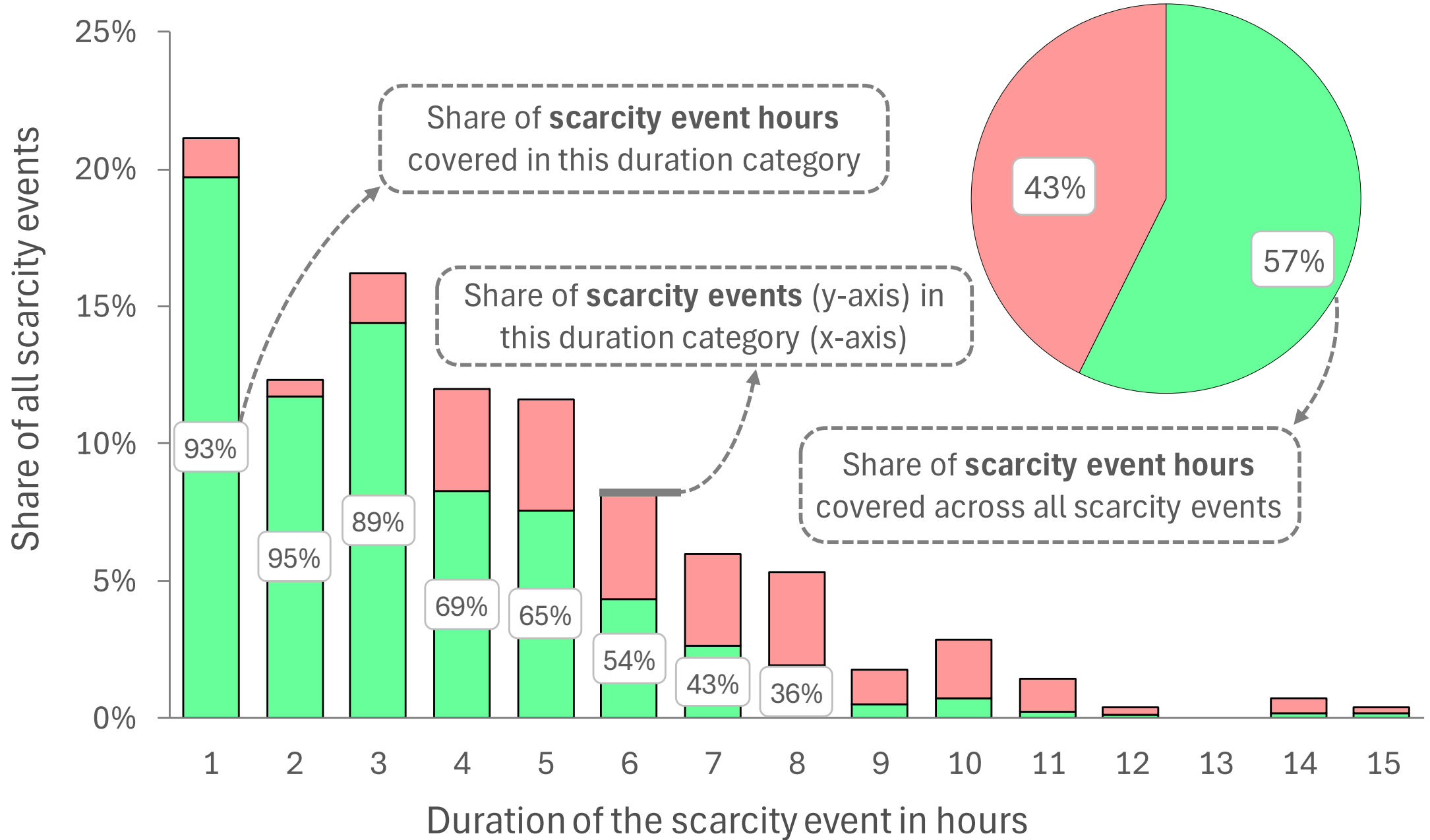


# Before the results...

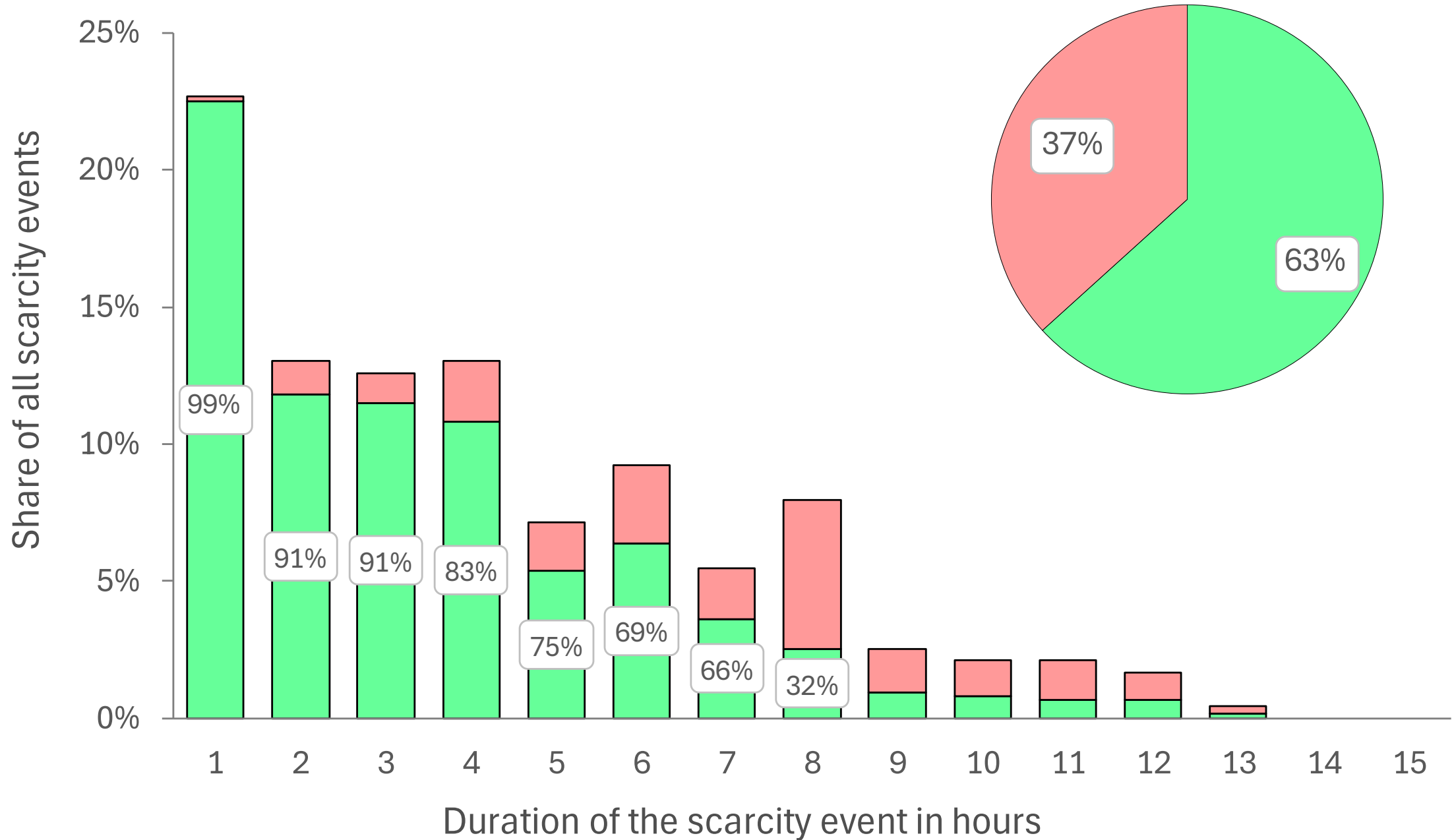
## ... what did we assume?

- 100% of Belgian residential heat pumps react
- 100% of heat pump owners allow the indoor temperature to drop by at least 2°C
- We ignore the risk of heat pump flex recovery causing a new scarcity event

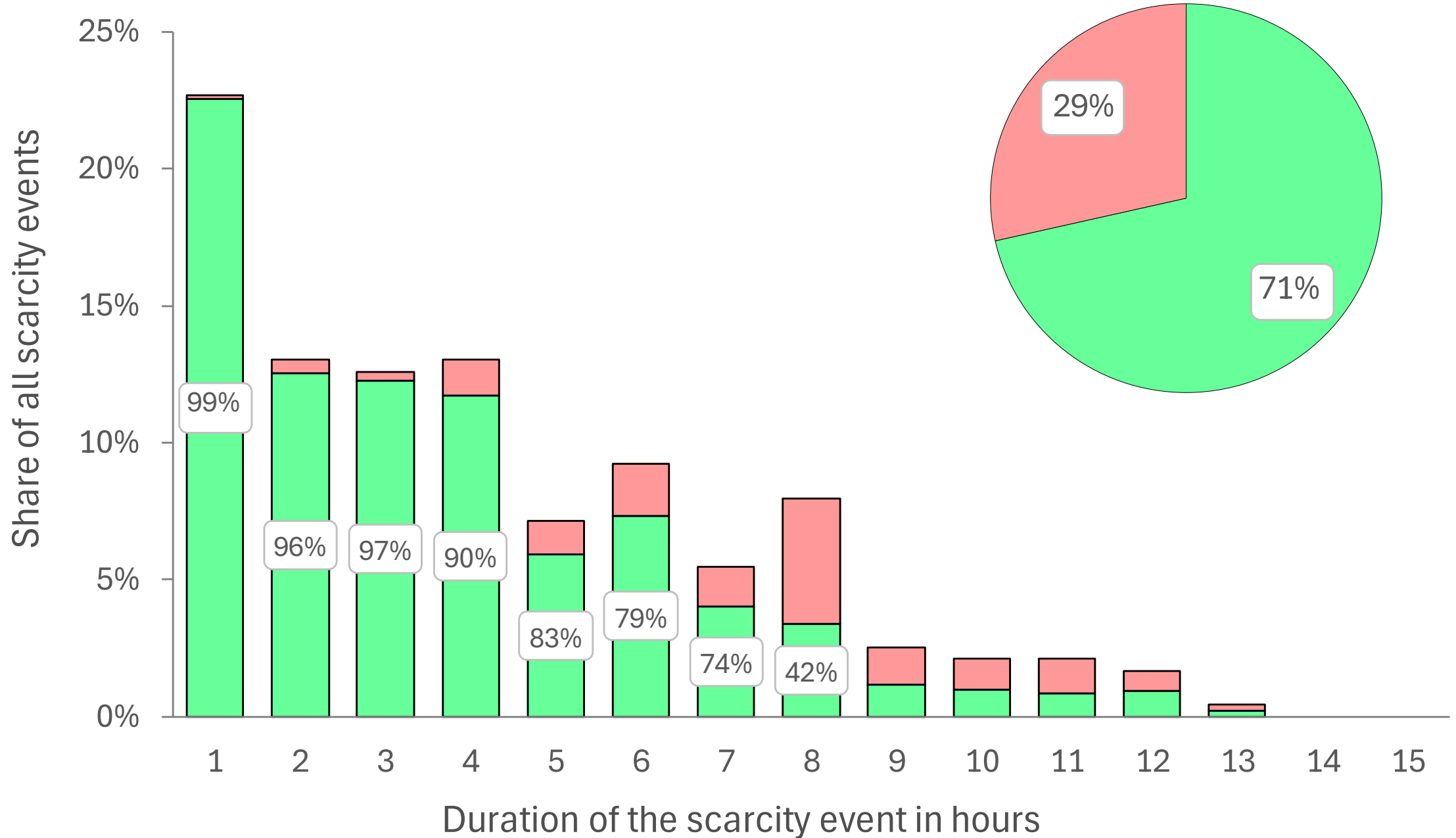
# 2030, threshold 19°C



# 2034, threshold 19°C



# 2034, threshold 17°C



# What do we conclude from this?

- Heat pumps can often be **turned off for several hours** without a significant impact on **comfort**
- This enables heat pump flexibility to play **a significant role** in **dealing with short-term scarcity events** in the electricity system
- Heat pump flexibility is **no panacea**, some scarcity events fundamentally cannot be addressed by it alone



[flexsys-project.be](https://flexsys-project.be)

- 1 What is FlexSys?
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# Would you give someone else control?

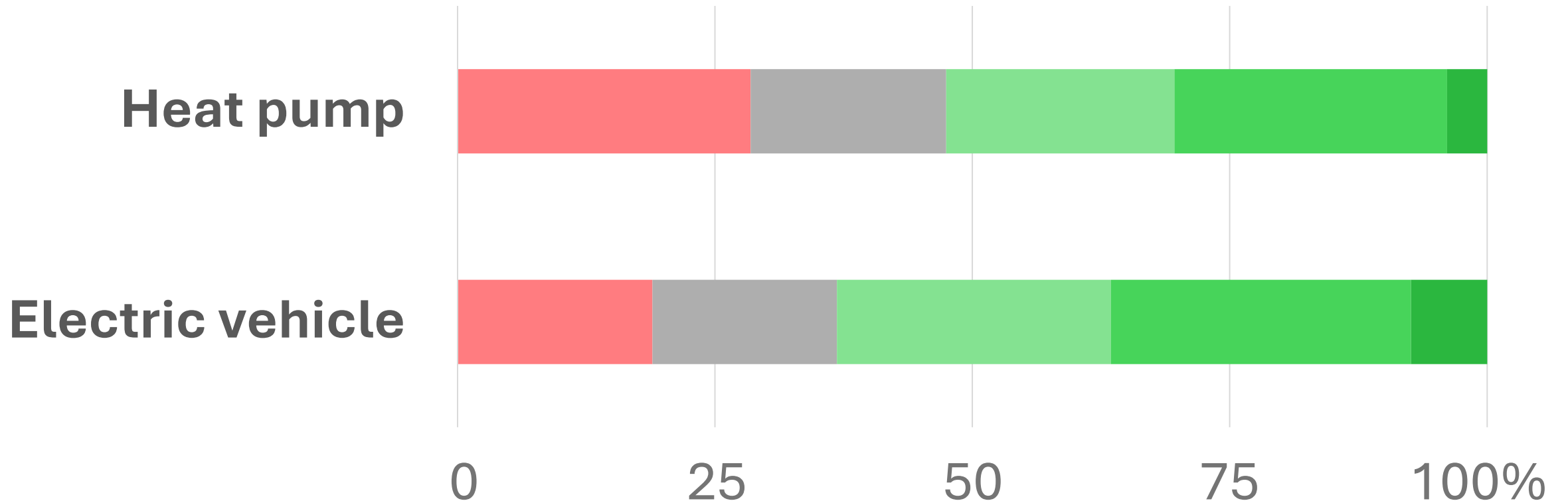
**no**

**unsure**

**only if I am  
notified and  
I can overrule**

**only if  
I can  
overrule**

**yes**



By how many degrees can a **flexible heat pump** deviate from your ideal temperature?



1°C		
Once per month	Once per week	Once per day

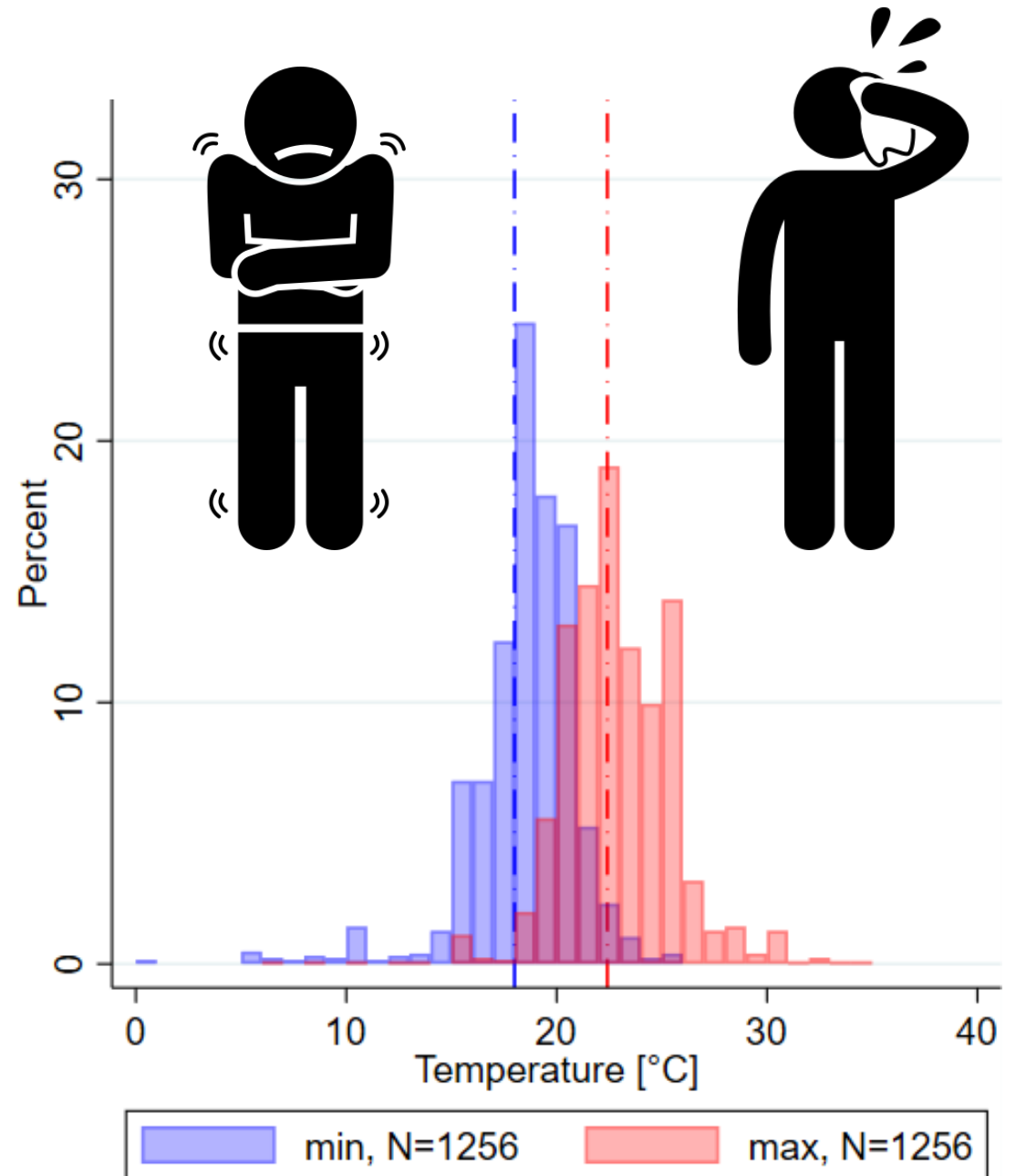
**OK** for an reduction of  $\geq 10\%$  in my annual heating cost

**OK** for an reduction of  $\geq 30\%$  in my annual heating cost

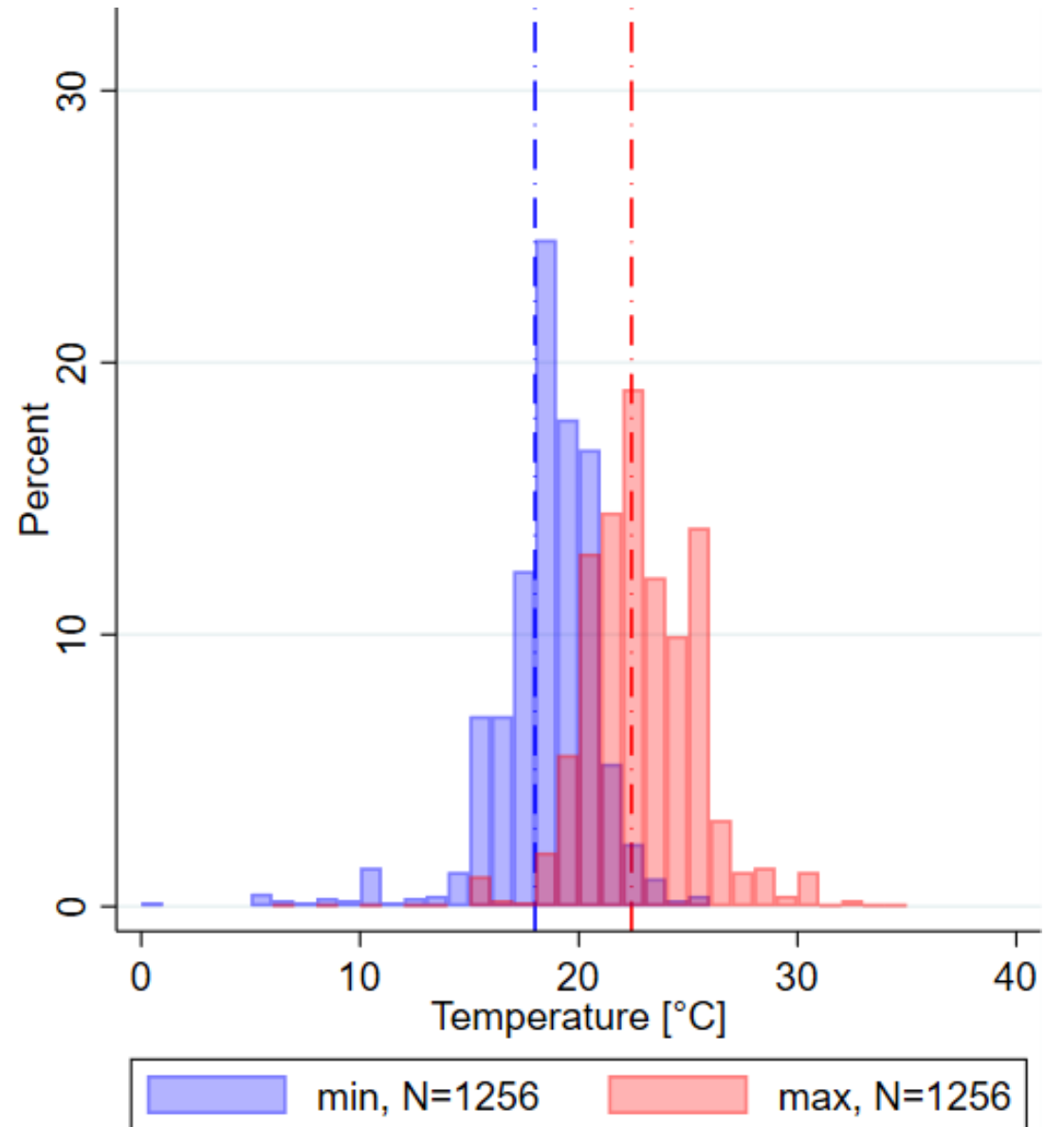
**Not OK** for an reduction of  $\geq 30\%$  in my annual heating cost

# People have diverse comfort preferences

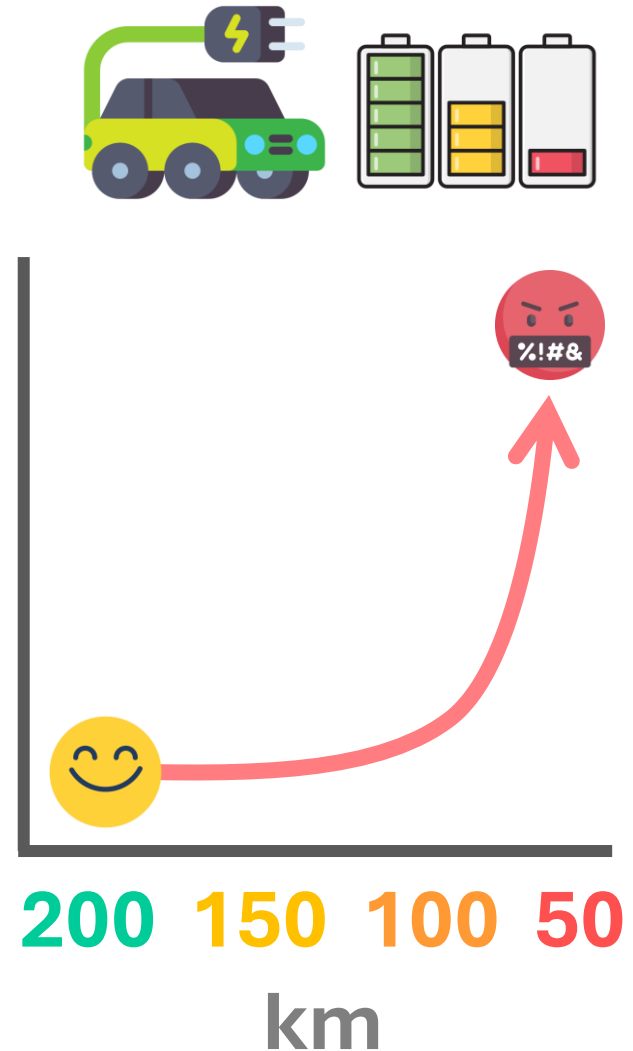
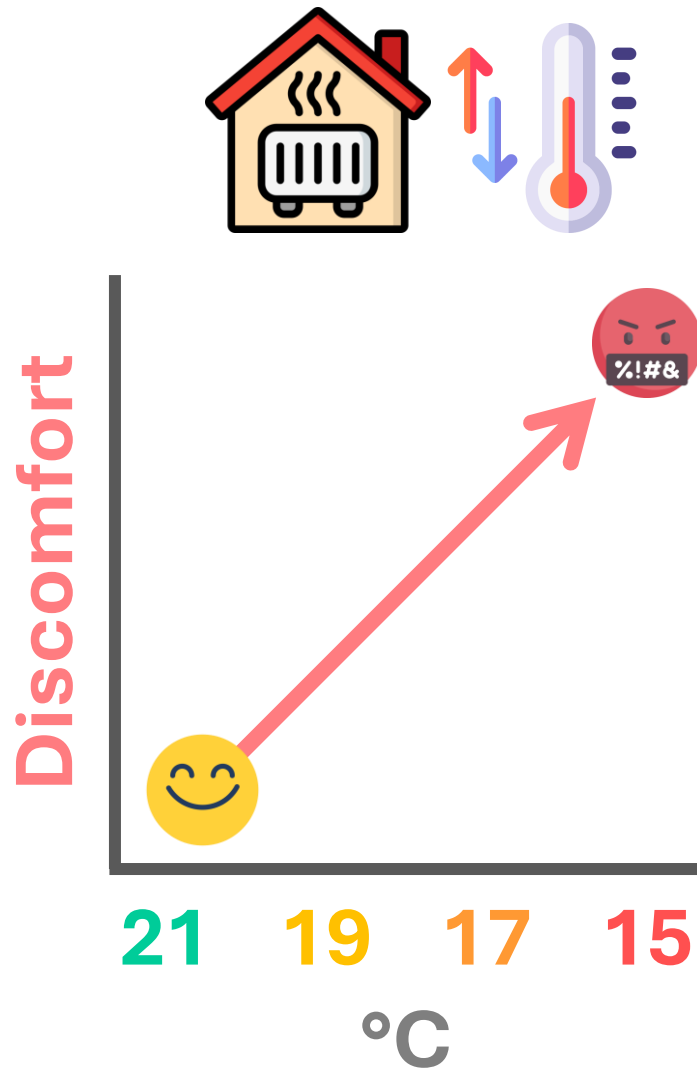
For example in terms of **ideal indoor temperature**



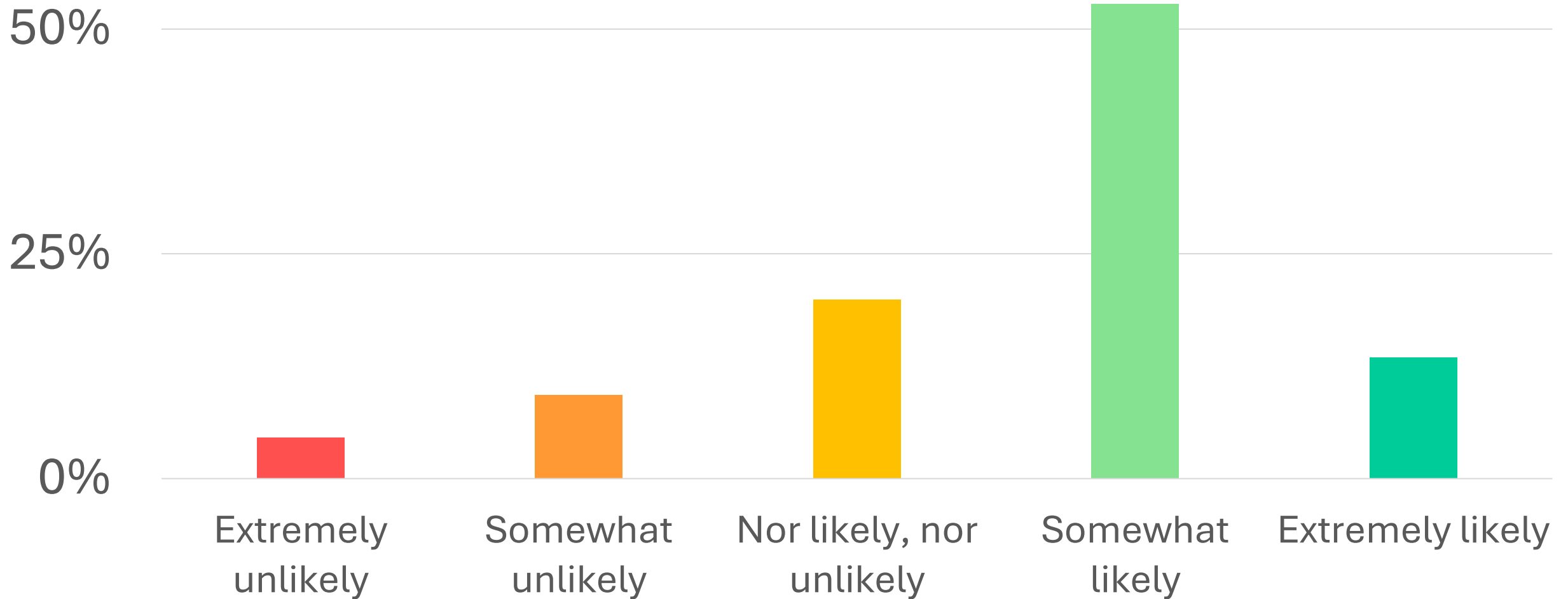
# Stated preferences often differ from revealed preferences

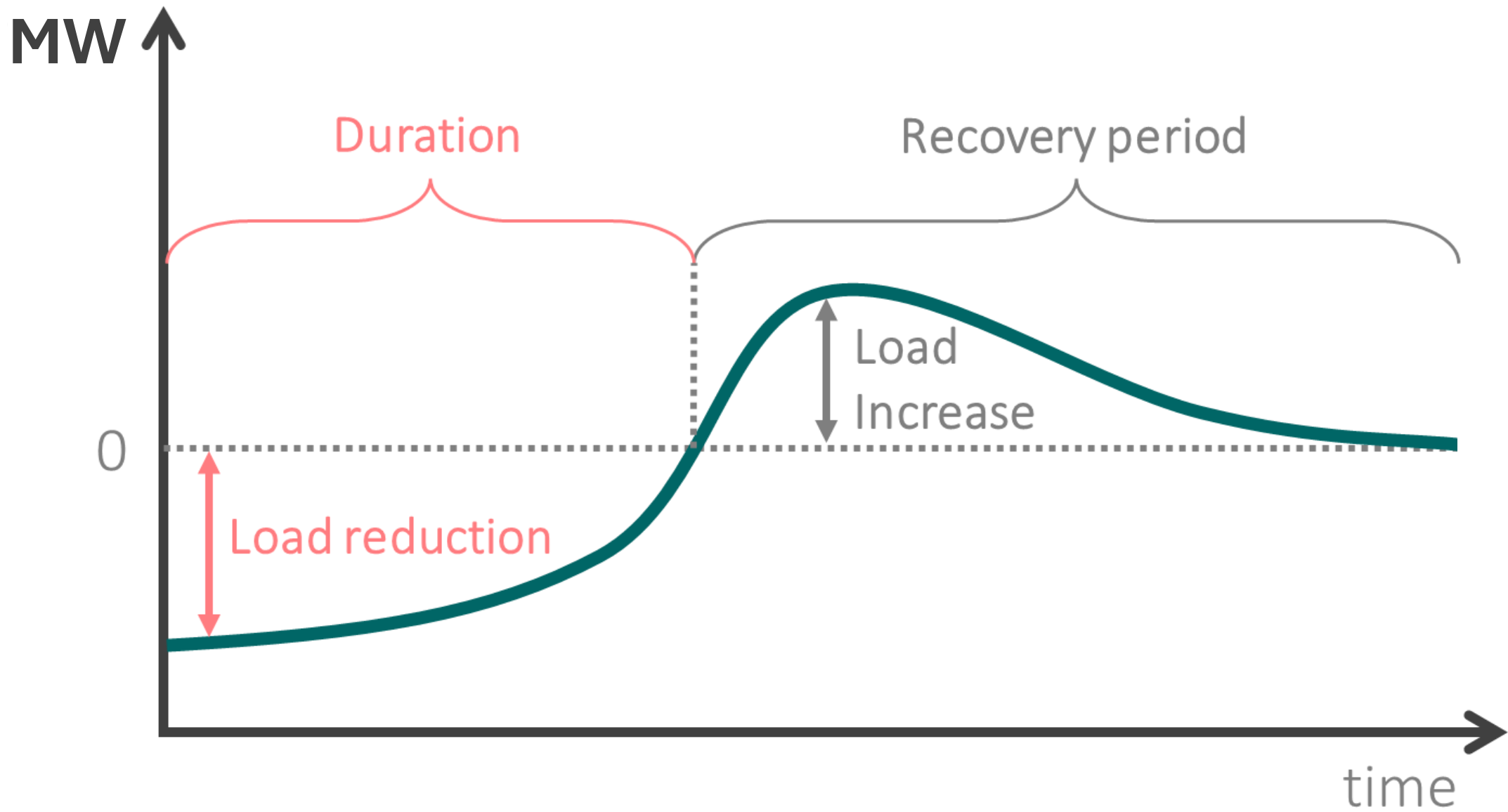


# People care differently about the impact of flex on temperature and driving range

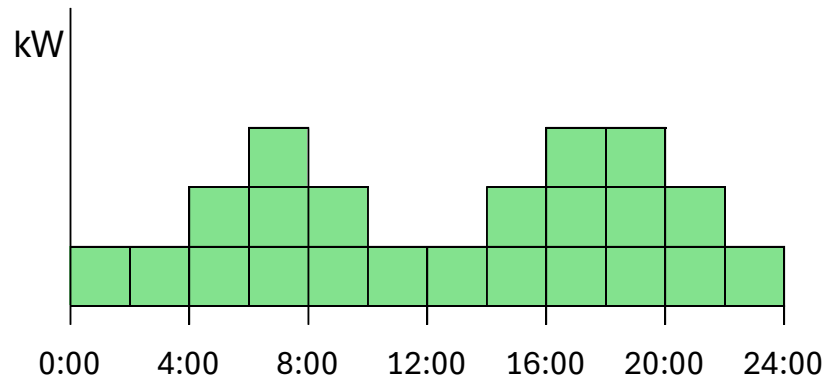


# If offered to you, how likely are you to enroll in a flexibility program?

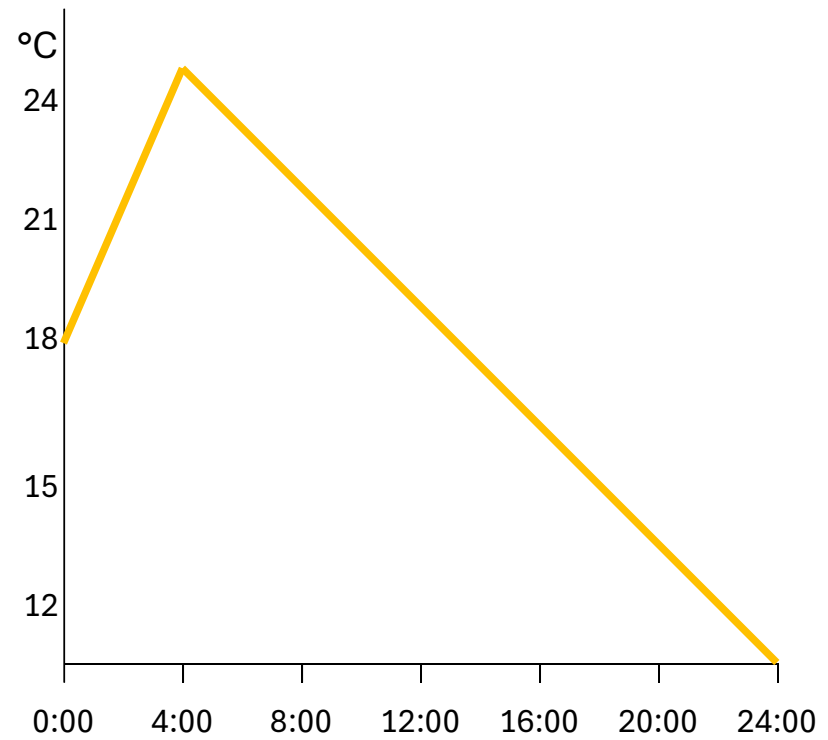
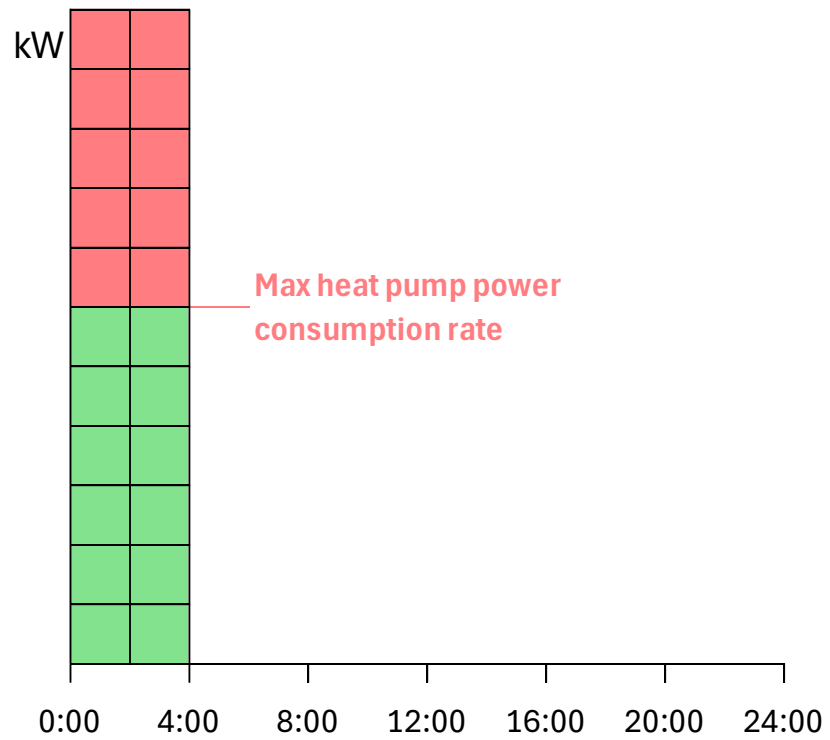
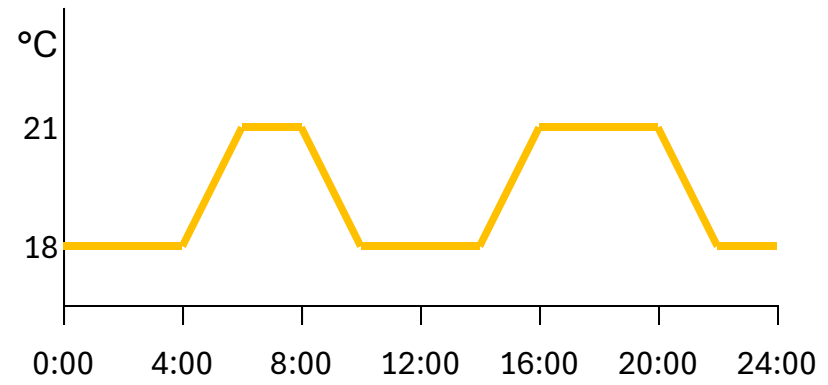


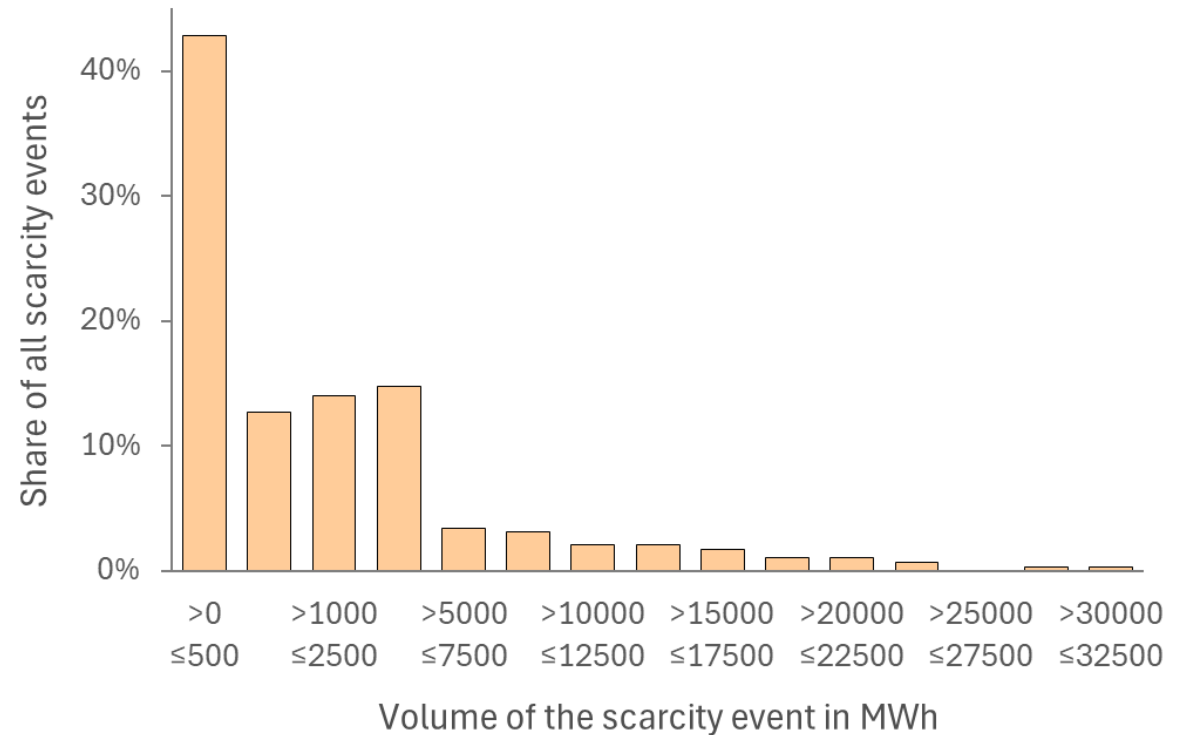
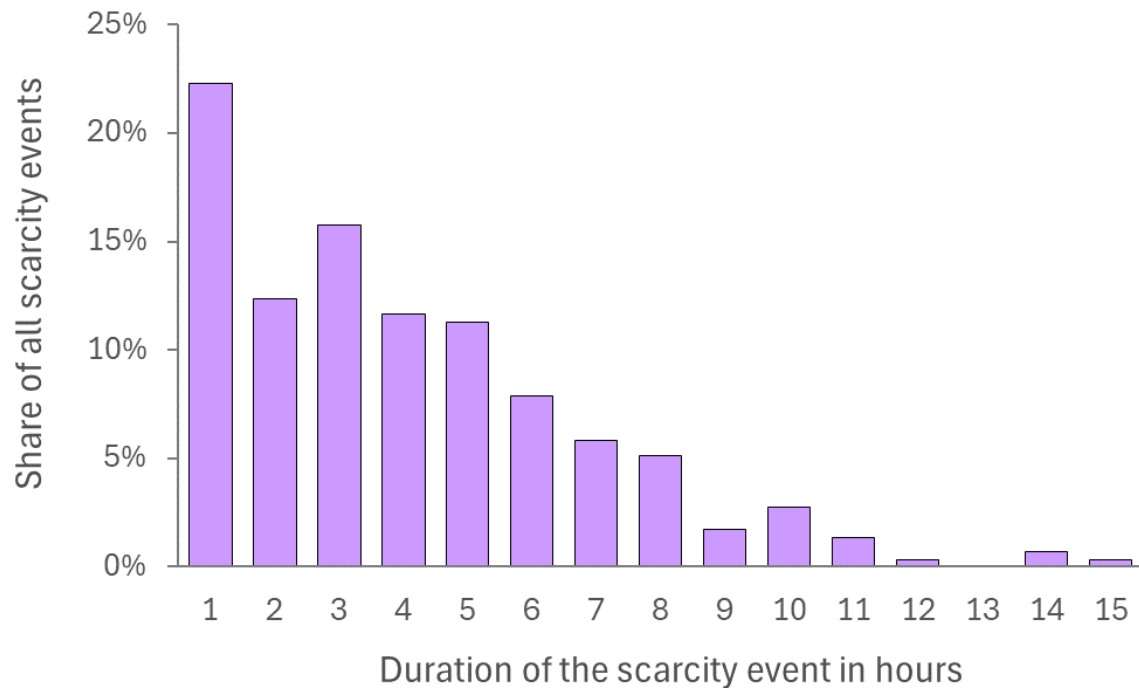
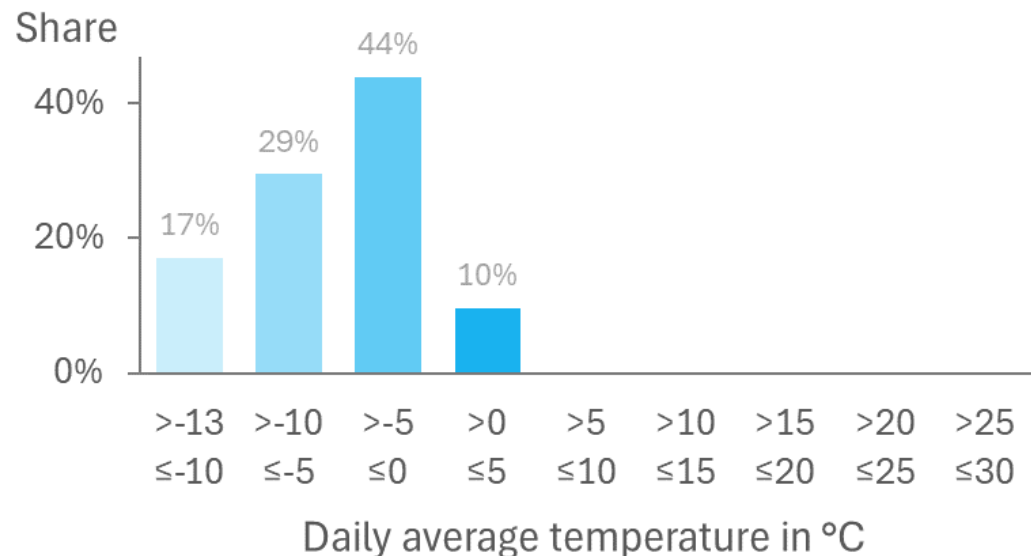
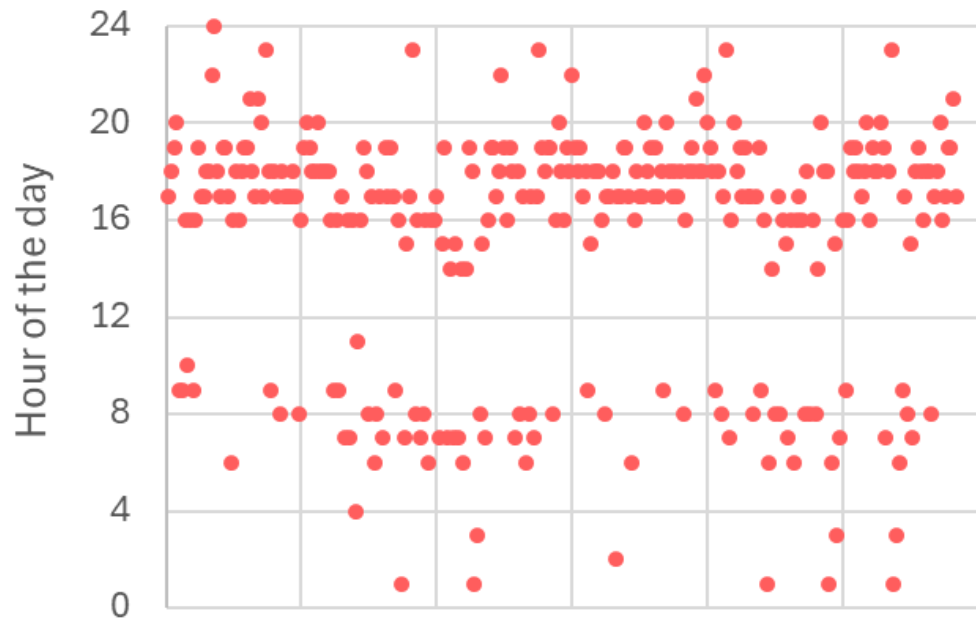


### Heat pump electricity consumption

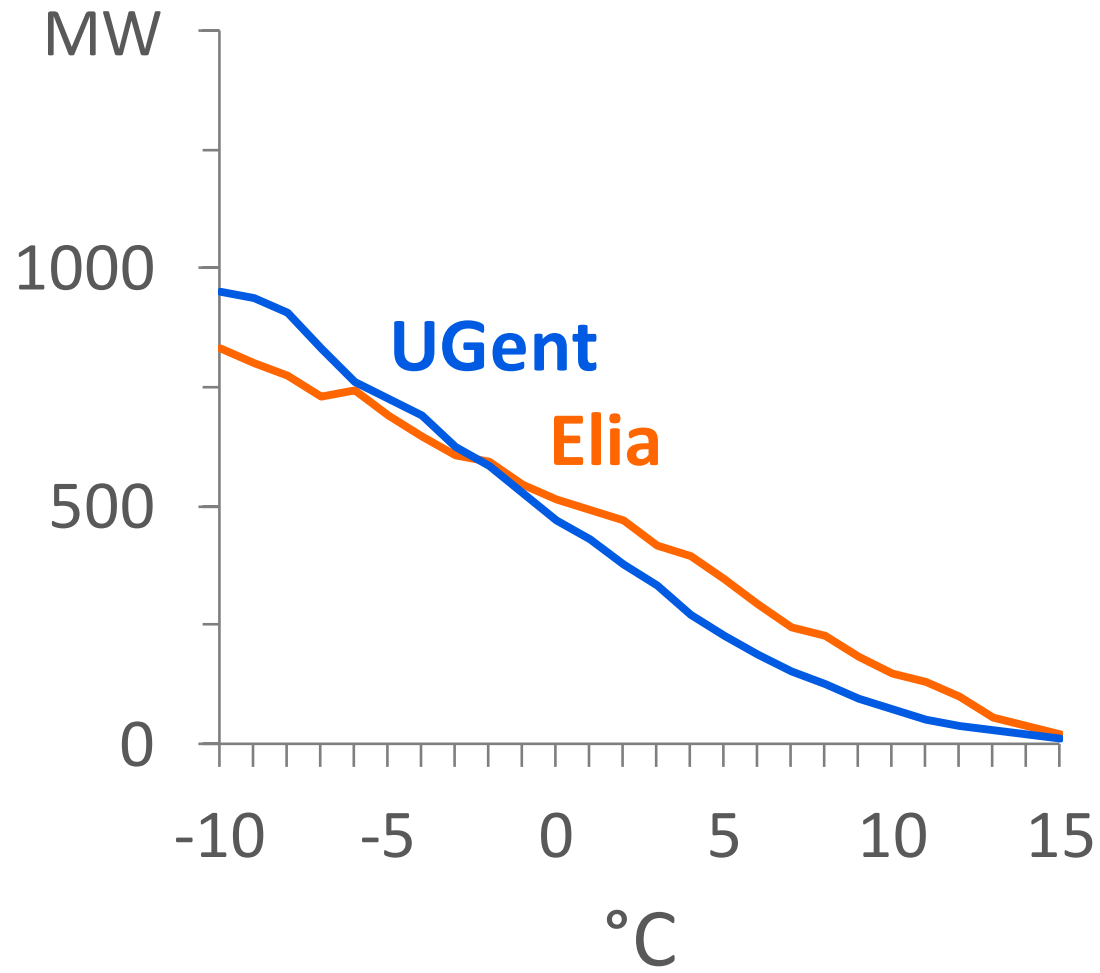


### Indoor temperature

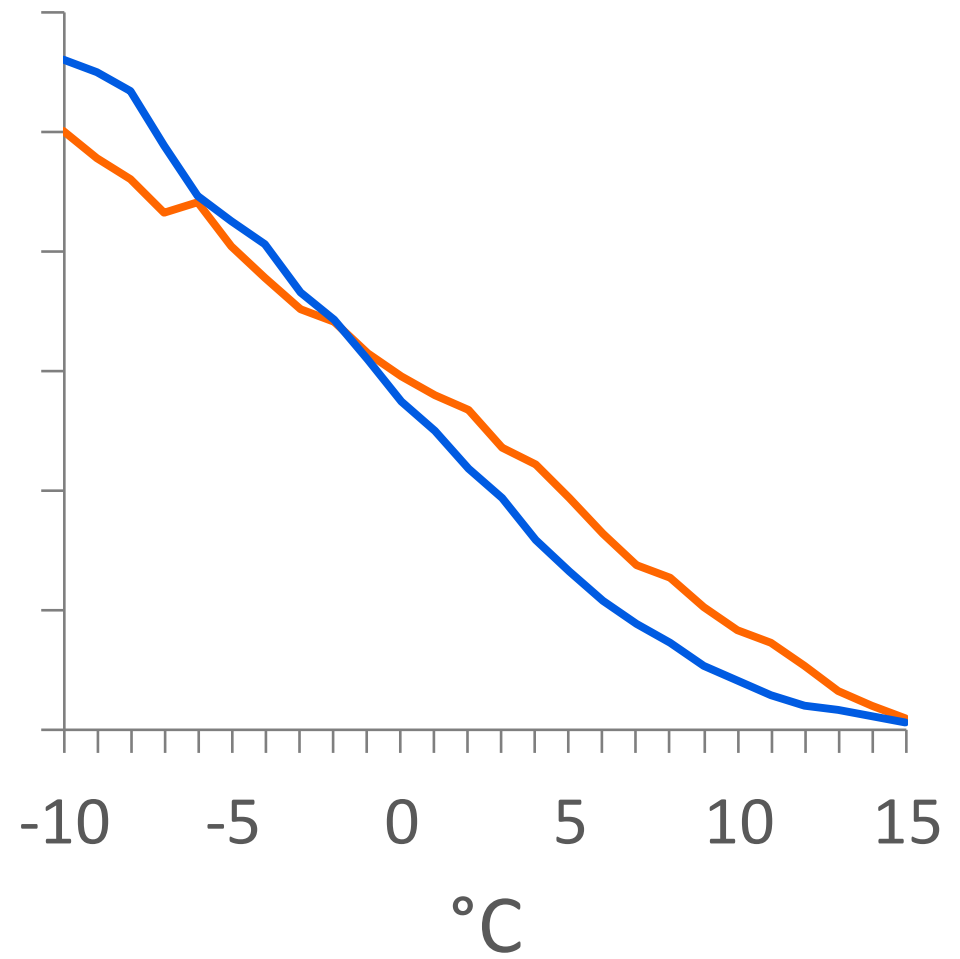




2030



2034



# Heating a home with a heat pump for one hour:

## Assumptions behind the table:



pump  
 temperature that needs to  
 1°C

table:

detached home  
 envelope label B  
 an indoor  
 C for one hour,  
 de, then:

umption of the heat  
 $Wh_e$   
 raised to the  
 $kWh_{th}$

- COP will be 3

Building Type	Building Volume (m <sup>3</sup> )		Building Area (m <sup>2</sup> )		Building Envelope Label
Apartment	300	M	100	M	A
Apartment	300	M	100	M	B
Apartment	300	M	100	M	C
Terraced	437	S	126	S	A
Terraced	437	S	126	S	B
Terraced	437	S	126	S	C
Terraced	475	M	160	M	A
Terraced	475	M	160	M	B
Terraced	475	M	160	M	C
Terraced	547	L	199	L	A
Terraced	547	L	199	L	B
Terraced	547	L	199	L	C
Detached	460	S	146	S	A
Detached	460	S	146	S	B
Detached	460	S	146	S	C
Detached	622	M	199	M	A
Detached	622	M	199	M	B
Detached	622	M	199	M	C
Detached	798	L	277	L	A
Detached	798	L	277	L	B
Detached	798	L	277	L	C

Heat pump electricity consumption (kWh <sub>e</sub> )		
-5°C	0°C	5°C
0.8	0.6	0.2
1.3	0.7	0.3
1.4	0.8	0.3
1.6	0.8	0.4
2.3	1.4	0.6
3.2	2.0	0.9
2.0	1.0	0.4
3.0	1.8	0.8
4.2	2.4	0.9
1.9	1.0	0.4
2.9	1.8	0.8
4.2	2.5	1.0
2.0	1.1	0.5
3.2	2.0	0.9
4.7	2.9	1.3
2.3	1.2	0.6
3.8	2.3	1.1
5.6	3.3	1.6
2.8	1.6	0.8
4.6	2.9	1.4
7.0	4.3	2.0

Heat production (kWh <sub>th</sub> )		
-5°C	0°C	5°C
1.8	1.6	0.9
2.7	2.1	1.4
3.0	2.1	1.3
3.6	2.8	1.9
5.2	4.1	2.9
6.9	5.3	3.6
4.5	3.3	2.0
6.9	5.4	3.6
8.8	6.5	4.0
4.4	3.4	2.1
6.8	5.3	3.6
9.0	6.8	4.3
4.8	3.8	2.7
7.6	6.0	4.4
10.2	7.8	5.7
5.7	4.5	3.2
9.0	7.0	5.2
12.1	8.3	6.8
6.9	5.5	3.8
11.1	8.8	6.4
15.0	11.6	8.3

Buffer size required (liters of water)		
-5°C	0°C	5°C
78	71	41
118	89	59
128	92	55
155	120	80
226	178	126
298	230	157
193	143	86
299	231	155
380	279	171
190	146	90
293	229	155
386	292	187
206	162	117
329	259	190
438	338	245
243	192	138
386	303	223
522	402	291
298	235	165
478	377	274
644	497	356

Disclaimer: COP is not exactly equal to heat production divided by electricity consumption because the table shows values rounded up to one value behind the decimal point, leading to rounding errors

# Academic research

Grid aspects of electrification and flexibility

Technical potential of EV, HP, batteries, ... to provide flexibility

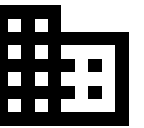
Modelling and technical aspects of heat pumps

Potential of building physics and DHW buffers to store energy

User behavior aspects of residential flexibility

Economic analysis

Belgian- and EU wide energy system modelling



# The past ... and the future

Past/current  
energy system

Current/future  
energy system

